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# ANNALS

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# INSTRUCTIONS TO AUTHORS

1. MATERIAL should be original and not published elsewhere, in whole or in part.

2. LAYOUT should be as follows:

- (a) *Centred masthead to consist of*  
 Title: informative but concise, without abbreviations and not including the names of new genera or species  
 Author's(s') name(s)  
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 Number of illustrations (figures, enumerated maps and tables, in this order)
- (b) *Abstract* of not more than 200 words, intelligible to the reader without reference to the text
- (c) *Table of contents* giving hierarchy of headings and subheadings
- (d) *Introduction*
- (e) *Subject-matter* of the paper, divided into sections to correspond with those given in table of contents
- (f) *Summary*, if paper is lengthy
- (g) *Acknowledgements*
- (h) *References*
- (i) *Abbreviations*, where these are numerous

3. MANUSCRIPT, to be submitted in triplicate, should be typewritten and neat, double spaced with 2.5 cm margins all round. First lines of paragraphs should be indented. Tables and a list of legends for illustrations should be typed separately, their positions indicated in the text. All pages should be numbered consecutively.

Major headings of the paper are centred capitals; first subheadings are shouldered small capitals; second subheadings are shouldered italics; third subheadings are indented, shouldered italics. Further subdivisions should be avoided, as also enumeration (never roman numerals) of headings and abbreviations.

Footnotes should be avoided unless they are short and essential.

Only generic and specific names should be underlined to indicate italics; all other marking up should be left to editor and publisher.

4. ILLUSTRATIONS should be reducible to a size not exceeding 12 × 18 cm (19 cm including legend); the reduction or enlargement required should be indicated; originals larger than 35 × 47 cm should not be submitted; photographs should be rectangular in shape and final size. A metric scale should appear with all illustrations, otherwise magnification or reduction should be given in the legend; if the latter, then the final reduction or enlargement should be taken into consideration.

All illustrations, whether line drawings or photographs, should be termed figures (plates are not printed; half-tones will appear in their proper place in the text) and numbered in a single series. Items of composite figures should be designated by capital letters; lettering of figures is not set in type and should be in lower-case letters.

The number of the figure should be lightly marked in pencil on the back of each illustration.

5. REFERENCES cited in text and synonymies should all be included in the list at the end of the paper, using the Harvard System (*ibid.*, *idem*, *loc. cit.*, *op. cit.* are not acceptable):

(a) Author's name and year of publication given in text, e.g.:

- 'Smith (1969) describes ...'
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*Note:* no comma separating name and year  
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(b) Full references at the end of the paper, arranged alphabetically by names, chronologically within each name, with suffixes *a*, *b*, etc. to the year for more than one paper by the same author in that year, e.g. Smith (1969a, 1969b) and not Smith (1969, 1969a).

For books give title in italics, edition, volume number, place of publication, publisher.

For journal article give title of article, title of journal in italics (abbreviated according to the *World list of scientific periodicals*, 4th ed. London: Butterworths, 1963), series in parentheses, volume number, part number (only if independently paged) in parentheses, pagination (first and last pages of article).

*Examples* (note capitalization and punctuation)

- BULLOUGH, W. S. 1960. *Practical invertebrate anatomy*. 2nd ed. London: Macmillan.
- FISCHER, P.-H. 1948. Données sur la résistance et de le vitalité des mollusques. *J. Conch.*, Paris 88: 100-140.
- FISCHER, P.-H., DUVAL, M. & RAFFY, A. 1933. Études sur les échanges respiratoires des littorines. *Archs Zool. exp. gén.* 74: 627-634.
- KOHN, A. J. 1960a. Ecological notes on *Conus* (Mollusca: Gastropoda) in the Trincomalee region of Ceylon. *Ann. Mag. nat. Hist.* (13) 2: 309-320.
- KOHN, A. J. 1960b. Spawning behaviour, egg masses and larval development in *Conus* from the Indian Ocean. *Bull. Bingham oceanogr. Coll.* 17 (4): 1-51.
- THIELE, J. 1910. Mollusca: B. Polyplacophora, Gastropoda marina, Bivalvia. In: SCHULTZE, L. *Zoologische und anthropologische Ergebnisse einer Forschungsreise im westlichen und zentralen Süd-Afrika* 4: 269-270. Jena: Fischer. *Denkschr. med.-naturw. Ges. Jena* 16: 269-270.

(continued inside back cover)



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A NEW GENUS OF LATE TERTIARY PENGUIN  
FROM LANGEBAANWEG, SOUTH AFRICA

By  
GEORGE GAYLORD SIMPSON

Cape Town Kaapstad

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# A NEW GENUS OF LATE TERTIARY PENGUIN FROM LANGEBAANWEG, SOUTH AFRICA

By

GEORGE GAYLORD SIMPSON

*The Simroe Foundation, 5151 East Holmes Street, Tucson, Arizona 85711*

(With 5 figures and 3 tables)

[MS. accepted 11 December 1978]

## ABSTRACT

Additional specimens of penguin bones from the 'E' Quarry in the latest Miocene/early Pliocene Varswater Formation make possible the identification of the larger of the two penguin taxa in that fauna and its definition as a new genus and species, *Dege hendeyi*.

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## INTRODUCTION

In two previous papers (Simpson 1971, 1975) an extinct genus and species of penguins, *Inguza predemersus*, was described and named from the late Tertiary of Langebaanweg. It was noted that a second, clearly distinct taxon occurred in the same deposit, but the specimens then at hand did not suffice for adequate identification or, if new, definition of that taxon. Specimens subsequently collected, although still not ideal, do suffice for those purposes and are here described and named as a new genus and species.

The specimens are all from the 'E' Quarry in the Varswater Formation in the vicinity of Langebaanweg, Cape Province. The Varswater Formation is of very late Miocene and/or early Pliocene age (Hendey 1978). The quarry and its stratigraphy have been carefully described by Hendey (1976), and those data need not be repeated here. Hendey has shown that the rich faunas of this formation represent a number of different environments—marine, estuarine, fluvatile, and terrestrial. Almost all known fossil penguins have been found in marine beds but generally in those deposited near shore or in distinctly littoral conditions. The Varswater penguins also have some marine associates, but the overall fauna of this varied formation, especially as regards the mammals except for cetaceans, a seal and an otter, is predominantly nonaquatic.

Most of the specimens here studied come from the middle member of the Varswater Formation, formerly (Hendey 1974) designated as 'Bed 2' but now (Hendey 1976) as the Quartzose Sand Member. Some, however, may be either



from that member or from one of two fossiliferous beds, 3aS and 3aN of Hendey, in the overlying Pelletal Phosphorite Member (formerly 'Bed 3'). The field data provided by Hendey are given below for each specimen listed in the hypodigm of the new species.

All specimens are in the South African Museum. All bear catalogue numbers with the prefix (SAM-PQ). As that prefix is uniform throughout, only the distinctive locality prefix (L) and numerical part of the catalogue designation will be given hereafter.

All measurements are in millimetres. In Tables 2 and 3 the following abbreviations are used:

- N number of specimens in sample.
- OR observed range.
- $\bar{X} \pm$  sample mean and its standard error.
- $S \pm$  sample estimate of standard deviation and its standard error.
- $V \pm$  sample estimate of coefficient of variation and its standard error.

Most of the designations and definitions of the dimensions involved in the tables are among those used in Simpson (1975) as follows:

Humerus:

- a. Maximum longitudinal dimension.
- b. Width of shaft about one-third of the distance distal to head.
- c. Width of shaft about two-thirds of distance distal to head.
- d. Distance from radial condyle to longest distal process.

Femur:

- a. Distance from the hollow between head and trochanter to that between distal condyles.
- b. Proximal width.
- c. Distal width.

Tibiotarsus:

- a. Distance from the proximal articulation, excluding the crest, to the hollow between distal condyles.
- b. Distal width.

The fragmentary nature of the three partial tarsometatarsi prevents use of standard dimensions (*a-c* in Simpson 1975) for this bone but the following *ad hoc* dimension is used:

Tarsometatarsus:

- d. Width across distal ends (phalangeal articulations) of metacarpals II-III.

## SYSTEMATICS

## Order SPHENISCIFORMES

## Family Spheniscidae

*Dege* gen. nov.*Etymology*

*Dege*, pronounced approximately *day-gay*, is an augmentative form of Swahili *ndege*, 'bird', hence 'big bird'. It is hoped that, as with *Inguza*, this will be an interesting change from the now rather stereotyped names of fossil penguins based on classical roots. There are, of course, larger African birds, but 'big bird' is appropriate because the type-species of *Dege* is larger than that of *Inguza* and also larger than the living African penguin, *Spheniscus demersus*. There seems to be no simple Swahili word for 'penguin' and in that language a penguin is designated descriptively, for example, as *ndege ya nchi za baridi*, approximately 'cold country bird'.

*Dege* is arbitrarily considered masculine in taxonomic usage.

*Type-species*

*Dege hendeyi* sp. nov.

*Included species*

Type only.

*Known distribution*

Langebaanian latest Miocene/early Pliocene in the Quartzose Sand Member and perhaps the Pelletal Phosphorite Member of the Varswater Formation near Langebaanweg.

*Diagnosis*

Tarsometatarsus short and stout. Medial intermetatarsal foramen present, relatively proximal and small, plantar opening more radial than in *Inguza* or *Aptenodytes* and *Pygoscelis* but less medial than in *Spheniscus* or most other Recent penguins. Medial calcaneal ridge not entire on known specimens but apparently weakly developed. Humerus with strongly bipartite tricipital fossa, dorsal part deeper but smaller, ridge between the two parts of the fossa parallel to long axis of bone. Latissimus dorsi insertion small, circular, convex. Shaft slightly bowed, not distinctly sigmoid, slightly wider distally than proximally. Preaxial angle feeble or absent. Femur and tibiotarsus sphenisciform, without marked peculiarities. (Figs 1-5.)

*Discussion*

Apart from size and proportions, the tarsometatarsus is especially distinctive in the position and course of the medial intermetatarsal foramen (the inner proximal foramen of Zusi 1975). The plantar opening is somewhat broken on



Fig. 1. Dorsal and plantar views of *Dege hendeyi* holotype (partial left tarsometatarsus, L28455) from Langebaanweg. (Twice natural size.)

specimen L28455, holotype of the type-species, but seems clearly to have been in a position unlike that in any other penguin known to me. Zusi (1975) and others have noted that this opening is on the medial side of a prominent calcaneal ridge in most Recent genera, but less medial and below a less prominent ridge in *Aptenodytes* and *Pygoscelis*. In *Dege* it is apparently in a position more or less intermediate between those two states. It is not known which, if either,



Fig. 2. Dorsal, ventral and posterior views of *Dege hendeyi* left humerus (L55005) from Langebaanweg. (Natural size.)





Fig. 3. Distal view of *Dege hendeyi* left humerus (L55010) from Langebaanweg. (Twice natural size.)

state is more primitive. The humerus is less distinctive and is within the rather stereotyped penguin pattern, but in detail is not quite like that of any other genus in which this part is known.

The only known penguins other than *Inguza* and *Dege* that may be of comparable age are three specimens from Motunau Beach on the South Island of New Zealand (Marples 1960; Simpson 1972). This Pliocene locality is about  $10^{\circ}$  farther south and almost  $156^{\circ}$  farther east than Langebaanweg, but that alone does not necessarily preclude generic relationships. Some living genera



Fig. 4. Anterior and posterior views of *Dege hendeyi* left femur (L28217) from Langebaanweg. (Natural size.)

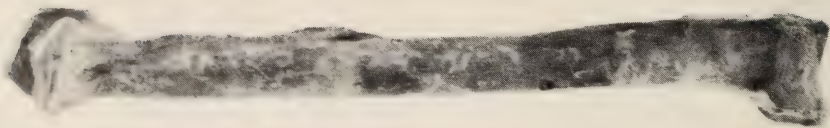


Fig. 5. Anterior view of *Dege hendeyi* right tibiotarsus (L5503) from Langebaanweg. (Natural size.)

have comparably wide ranges. However, the known Langebaanweg and Motunau fossil penguins are quite different. Known parts of two of the Motunau penguins are not generically distinguishable from the living genera *Pygoscelis* and *Aptenodytes* and are referred to those genera as extinct species. The humerus of *P. tyreei* can be compared with *Inguza* and *Dege* and the tarsometatarsus of *A. ridgeni* can be similarly compared as can other parts of living *Pygoscelis* and *Aptenodytes*. The diagnoses of *Inguza* and *Dege* include distinctions from *Pygoscelis* and *Aptenodytes* that are reasonably construed as of generic rank. The third Motunau genus, *Marplesornis*, can be compared mainly on the basis of a not quite perfect humerus, which differs from both *Inguza* and *Dege* in having an extraordinarily expanded and somewhat concave latissimus dorsi insertion and from *Dege* in having the shaft distinctly more expanded distally.

*Dege hendeyi* sp. nov.

*Etymology*

For Dr Q. B. Hendey, who supervised collecting of these and many other fossils at Langebaanweg and who has done so much research on the geology and fauna of that deposit.

*Holotype*

L28455, left tarsometatarsus with most of metatarsals II and III, lacking metatarsal IV\* and proximal articulation. From Quartzose Sand Member.

*Hypodigm*

Holotype and the following. From Quartzose Sand Member: L22985, fragment of left tarsometatarsus with most of distal end of metatarsal III; L28456, fragment of right tarsometatarsus with distal ends of metatarsals III and IV; L13154, right femur nearly complete; L25028, left femur nearly complete; L25807, right femur nearly complete; L28216, right femur nearly complete; L28217, left femur complete; L28222, left tibiotarsus complete. From Quartzose Sand Member or bed 3aN of Pelletal Phosphorite Member: L55004, left humerus with proximal and distal ends imperfect; L55005, left humerus with distal end imperfect; L55003, right tibiotarsus complete. From Quartzose

\* The missing metatarsal IV was found and restored to the holotype after this study was completed.

Sand Member or bed 3aS of Pelletal Phosphorite Member: slightly damaged proximal end of right humerus; L55010, well-preserved distal end of left humerus; L3656, left femur with proximal and distal ends slightly abraded.

#### Known distribution

As for the genus.

#### Diagnosis

Only known species of the genus. Measurements as in Tables 1 and 2.

TABLE 1

Measurements of specimens of *Dege hendeyi*.

(Specifications of measurements are given in the text.)

Tarsometatarsus . . . . .					<i>d</i>
Holotype 23018 . . . . .					12,7
Humerus		<i>a</i>	<i>b</i>	<i>c</i>	<i>d</i>
L55004 . . . . .	<i>c.</i> 69	12,8	14,0	—	—
L55005 . . . . .	<i>c.</i> 68,5	13,4	14,4	—	—
L55010 . . . . .	—	—	—	—	20,3
Tibiotarsus		<i>a</i>	<i>b</i>		
L55003 . . . . .	106,5	16,0			
L28222 . . . . .	108,2	15,3			

TABLE 2

Statistics on femora of *Dege hendeyi*.

(Specifications of variates and symbols of statistics are given in the text.)

Variate	N	OR	$\bar{X}$	S	V
<i>a</i> . . . . .	6	70,4-79,5	75,13±1,30	3,17±0,92	4,22±1,22
<i>b</i> . . . . .	5	17,3-18,6	18,16±0,25	0,56±0,18	3,88±0,97
<i>c</i> . . . . .	5	15,1-17,9	16,96±0,50	1,11±0,35	6,57±2,08

#### Discussion

*Inguza* and *Dege* are distinct genera, not necessarily more closely related to each other than to some other penguins, but they occur together and sorting or preliminary identification can most easily be made by the difference in size of their type-species. Comparable measurements of those species are given in Table 3.

As noted above, some of the specimens of *Dege hendeyi* may have come from the Pelletal Phosphorite Member, which overlies the Quartzose Sand Member and must be to some degree younger in age. Hendey (1976) has suggested that the differences may be appreciable and that further studies of the enlarged collection from the Pelletal Phosphorite Member may reveal some faunal difference, although this has not yet been clearly established. In the material here studied, it happens that specimen L3656, the only femur that may be from the Pelletal Phosphorite Member, is the largest of the six femora referred to *Dege hendeyi*. The difference is not great enough to warrant any taxonomic distinction, and as the matter now stands the whole lot could well, and probably does, represent a single, not even particularly variable species.



TABLE 3

Comparative dimensions of *Dege hendeyi* and *Inguza predemersus*.  
(Specifications of variates and symbols of statistics are given in the text.)

Variate	Species	N	OR	$\bar{X}$
Tarsometatarsus <i>d</i> . . . . .	<i>Dege hendeyi</i>	1	—	16,5
	<i>Inguza predemersus</i>	1	—	12,7
Humerus <i>a</i> . . . . .	<i>D. hendeyi</i>	2	68,5–69,0	68,75
	<i>I. predemersus</i>	2	57,5–59,0	58,25
	<i>D. hendeyi</i>	2	12,8–13,4	13,10
	<i>I. predemersus</i>	6	8,6–10,0	9,35
	<i>D. hendeyi</i>	2	14,0–14,4	14,20
	<i>I. predemersus</i>	5	10,0–11,7	10,98
	<i>D. hendeyi</i>	1	—	20,30
	<i>I. predemersus</i>	4	17,8–19,3	18,60
	<i>D. hendeyi</i>	6	70,4–79,5	75,13
	<i>I. predemersus</i>	3	59,8–62,3	61,20
Femur <i>a</i> . . . . .	<i>D. hendeyi</i>	5	17,3–18,6	18,16
	<i>I. predemersus</i>	2	13,9–14,4	14,15
	<i>D. hendeyi</i>	5	15,1–17,9	16,96
	<i>I. predemersus</i>	4	13,3–14,5	13,78
	<i>D. hendeyi</i>	5	15,1–17,9	16,96
	<i>I. predemersus</i>	4	13,3–14,5	13,78

All the penguin bones from this deposit are dissociated, but they fall into two non-overlapping size groups and the ratios of measurements of non-homologous bones are similar to those of associated bones in Recent species and in the few fossil species in which associated bones have been found. It is highly probable that the known Langebaanweg specimens do represent just two species and are correctly sorted by size.

### ACKNOWLEDGEMENTS

As in previous studies of South African fossil and Recent penguins, I am greatly indebted to the South African Museum and to Dr Q. B. Hendey who arranged the loan of the fossil specimens, provided the field data on them, and reviewed the manuscript of this paper. Study was carried out at the Simroe Foundation and with support from the Department of Geosciences of the University of Arizona, Tucson, U.S.A.

The illustrations were supplied by the South African Museum.

### REFERENCES

- HENDEY, Q. B. 1974. The late Cenozoic Carnivora of the south-western Cape Province. *Ann. S. Afr. Mus.* **63**: 1–369.  
 HENDEY, Q. B. 1976. The Pliocene fossil occurrences in 'E' Quarry, Langebaanweg, South Africa. *Ann. S. Afr. Mus.* **69**: 215–247.  
 HENDEY, Q. B. 1978. The late Tertiary Hyaenidae from Langebaanweg, South Africa, and their relevance to the phylogeny of the family. *Ann. S. Afr. Mus.* **76**: 265–297.  
 MARPLES, B. J. 1960. A fossil penguin from the later Tertiary of North Canterbury. *Rec. Canterbury Mus.* **7**: 185–195.  
 SIMPSON, G. G. 1971. Fossil penguin from the late Cenozoic of South Africa. *Science* **171**: 1144–1145.

- SIMPSON, G. G. 1972. Pliocene penguins from North Canterbury, New Zealand. *Rec. Canterbury Mus.* 9: 159-182.
- SIMPSON, G. G. 1975. Notes on variation in penguins and on fossil penguins from the Pliocene of Langebaanweg, Cape Province, South Africa. *Ann. S. Afr. Mus.* 69: 59-72.
- ZUSI, R. L. 1975. An interpretation of skull structure in penguins.\* In: STONEHOUSE, B., ed. *The Biology of Penguins*: 59-86. London and Basingstoke: Macmillan.

\* This study also refers to postcranial bones and classification of Recent penguins.





6. SYSTEMATIC papers must conform to the *International code of zoological nomenclature* (particularly Articles 22 and 51).

Names of new taxa, combinations, synonyms, etc., when used for the first time, must be followed by the appropriate Latin (not English) abbreviation, e.g. gen. nov., sp. nov., comb. nov., syn. nov., etc.

An author's name when cited must follow the name of the taxon without intervening punctuation and not be abbreviated; if the year is added, a comma must separate author's name and year. The author's name (and date, if cited) must be placed in parentheses if a species or subspecies is transferred from its original genus. The name of a subsequent user of a scientific name must be separated from the scientific name by a colon.

Synonymy arrangement should be according to chronology of names, i.e. all published scientific names by which the species previously has been designated are listed in chronological order, with all references to that name following in chronological order, e.g.:

Family Nuculanidae

*Nuculana (Lembulus) bicuspidata* (Gould, 1845)

Figs 14–15A

*Nucula (Leda) bicuspidata* Gould, 1845: 37.

*Leda plicifera* A. Adams, 1856: 50.

*Laeda bicuspidata* Hanley, 1859: 118, pl. 228 (fig. 73). Sowerby, 1871: pl. 2 (fig. 8a–b).

*Nucula largillierii* Philippi, 1861: 87.

*Leda bicuspidata*: Nickles, 1950: 163, fig. 301; 1955: 110. Barnard, 1964: 234, figs 8–9.

Note punctuation in the above example:

comma separates author's name and year

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figures of plates are enclosed in parentheses to distinguish them from text-figures

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Synonymy arrangement according to chronology of bibliographic references, whereby the year is placed in front of each entry, and the synonym repeated in full for each entry, is not acceptable.

In describing new species, one specimen must be designated as the holotype; other specimens mentioned in the original description are to be designated paratypes; additional material not regarded as paratypes should be listed separately. The complete data (registration number, depository, description of specimen, locality, collector, date) of the holotype and paratypes must be recorded, e.g.:

*Holotype*

SAM-A13535 in the South African Museum, Cape Town. Adult female from mid-tide region, King's Beach Port Elizabeth (33°51'S 25°39'E), collected by A. Smith, 15 January 1973.

Note standard form of writing South African Museum registration numbers and date.

## 7. SPECIAL HOUSE RULES

### *Capital initial letters*

- (a) The Figures, Maps and Tables of the paper when referred to in the text  
e.g. '... the Figure depicting *C. namacolus* ...'; '... in *C. namacolus* (Fig. 10) ...'
- (b) The prefixes of prefixed surnames in all languages, when used in the text, if not preceded by initials or full names  
e.g. Du Toit but A. L. du Toit; Von Huene but F. von Huene
- (c) Scientific names, but not their vernacular derivatives  
e.g. Therocephalia, but therocephalian

Punctuation should be loose, omitting all not strictly necessary

Reference to the author should be expressed in the third person

Roman numerals should be converted to arabic, except when forming part of the title of a book or article, such as

'Revision of the Crustacea. Part VIII. The Amphipoda.'

Specific name must not stand alone, but be preceded by the generic name or its abbreviation to initial capital letter, provided the same generic name is used consecutively.

Name of new genus or species is not to be included in the title: it should be included in the abstract, counter to Recommendation 23 of the Code, to meet the requirements of Biological Abstracts.

GEORGE GAYLORD SIMPSON

A NEW GENUS OF LATE TERTIARY PENGUIN  
FROM LANGEBAANWEG, SOUTH AFRICA

VOLUME 78 PART 2

APRIL 1979

ISSN 0303-2515

507.68



# ANNALS

OF THE SOUTH AFRICAN  
MUSEUM



CAPE TOWN



## INSTRUCTIONS TO AUTHORS

1. MATERIAL should be original and not published elsewhere, in whole or in part.

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- (a) *Centred masthead to consist of*
  - Title: informative but concise, without abbreviations and not including the names of new genera or species
  - Author's(s') name(s)
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  - Number of illustrations (figures, enumerated maps and tables, in this order)
- (b) *Abstract* of not more than 200 words, intelligible to the reader without reference to the text
- (c) *Table of contents* giving hierarchy of headings and subheadings
- (d) *Introduction*
- (e) *Subject-matter* of the paper, divided into sections to correspond with those given in table of contents
- (f) *Summary*, if paper is lengthy
- (g) *Acknowledgements*
- (h) *References*
- (i) *Abbreviations*, where these are numerous

3. MANUSCRIPT, to be submitted in triplicate, should be typewritten and neat, double spaced with 2.5 cm margins all round. First lines of paragraphs should be indented. Tables and a list of legends for illustrations should be typed separately, their positions indicated in the text. All pages should be numbered consecutively.

Major headings of the paper are centred capitals; first subheadings are shouldered small capitals; second subheadings are shouldered italics; third subheadings are indented, shouldered italics. Further subdivisions should be avoided, as also enumeration (never roman numerals) of headings and abbreviations.

Footnotes should be avoided unless they are short and essential.

Only generic and specific names should be underlined to indicate italics; all other marking up should be left to editor and publisher.

4. ILLUSTRATIONS should be reducible to a size not exceeding 12 × 18 cm (19 cm including legend); the reduction or enlargement required should be indicated; originals larger than 35 × 47 cm should not be submitted; photographs should be rectangular in shape and final size. A metric scale should appear with all illustrations, otherwise magnification or reduction should be given in the legend; if the latter, then the final reduction or enlargement should be taken into consideration.

All illustrations, whether line drawings or photographs, should be termed figures (plates are not printed; half-tones will appear in their proper place in the text) and numbered in a single series. Items of composite figures should be designated by capital letters; lettering of figures is not set in type and should be in lower-case letters.

The number of the figure should be lightly marked in pencil on the back of each illustration.

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(a) Author's name and year of publication given in text, e.g.:

- 'Smith (1969) describes ...'
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(b) Full references at the end of the paper, arranged alphabetically by names, chronologically within each name, with suffixes *a*, *b*, etc. to the year for more than one paper by the same author in that year, e.g. Smith (1969a, 1969b) and not Smith (1969, 1969a).

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- FISCHER, P.-H., DUVAL, M. & RAFFY, A. 1933. Études sur les échanges respiratoires des littorines. *Archs Zool. exp. gén.* 74: 627-634.
- KOHN, A. J. 1960a. Ecological notes on *Conus* (Mollusca: Gastropoda) in the Trincomalee region of Ceylon. *Ann. Mag. nat. Hist.* (13) 2: 309-320.
- KOHN, A. J. 1960b. Spawning behaviour, egg masses and larval development in *Conus* from the Indian Ocean. *Bull. Bingham oceanogr. Coll.* 17 (4): 1-51.
- THIELE, J. 1910. Mollusca: B. Polyplacophora, Gastropoda marina, Bivalvia. In: SCHULTZE, L. *Zoologische und anthropologische Ergebnisse einer Forschungsreise im westlichen und zentralen Süd-Afrika* 4: 269-270. Jena: Fischer. *Denkschr. med.-naturw. Ges. Jena* 16: 269-270.

(continued inside back cover)

ANNALS OF THE SOUTH AFRICAN MUSEUM  
ANNALE VAN DIE SUID-AFRIKAANSE MUSEUM

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April 1979 April  
Part 2 Deel



CRETACEOUS FAUNAS FROM SOUTHERN AFRICA  
LOWER CRETACEOUS AMMONITES, INCLUDING  
A NEW BOCHIANITID GENUS, FROM  
UMGAZANA, TRANSKEI

By  
HERBERT CHRISTIAN KLINGER  
&  
WILLIAM JAMES KENNEDY

Cape Town Kaapstad

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By

HERBERT CHRISTIAN KLINGER

*South African Museum, Cape Town*

&

WILLIAM JAMES KENNEDY

*Geological Collections, University Museum, Oxford*

(With 5 figures)

[MS. accepted 19 December 1978]

ABSTRACT

The Umgazana Formation, outcropping at the mouth of the Umgazana River, south of Port St Johns, Transkei, southern Africa, has yielded a small but distinctive ammonite fauna consisting of *Neohoplloceras* sp. and abundant bochianitids referred to a new genus and species, *Umgazanicerias thieuloyi*, together with a specimen of *Bochianites* cf. *renevieri* (Ooster, 1860). The association dates the unit as Upper Valanginian, and contemporaneous with the better-known Uitenhage Formation of South Africa.

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INTRODUCTION

The term Umgazana Formation is applied to the small outcrop of Lower Cretaceous sediments exposed on the Umgazana (Mngazana) River, a little to the south of Port St Johns, Transkei, southern Africa (Rogers & Du Toit 1909; Du Toit 1912, 1920, 1954; Haughton 1969; Truswell 1967). Lithologies present are predominantly dark greenish conglomerates with some bands of coarse sandstone and grit. Occasional limestone lenticles yield invertebrate macrofossils, listed by previous authors as *Baculites*, *Pseudomelania*, *Trigonia* and *Thetironia*. The following plants are recorded: *Onchiopsis*, *Cladophlebis*, *Nilssonina*, *Dictyozamites* and *Otozamites*. The flora indicates the Umgazana Formation to be the equivalent of the better known Uitenhage Formation, and Cooper (1974) suggested the sequence to be of uppermost Valanginian date.

Recent micropalaentological investigations by McLachlan *et al.* (1977) suggest a Hauterivian/Valanginian date, whilst their samples yielded abundant

ammonites, including a bochianitid assemblage unlike that known from the Uitenhage Formation, or, indeed, anywhere else. The forms present are identified as:

*Neohoploceras* sp. indet.

*Umgazaniceras thieuloyi* gen. et sp. nov.

*Bochianites* cf. *renevieri* (Ooster, 1860)

Together these confirm the previous Upper Valanginian dating of the Umgazana Formation

## SYSTEMATIC PALAEONTOLOGY

Family **Bochianitidae** Spath, 1922

Subfamily Bochianitinae Spath, 1922

Genus *Umgazaniceras* nov.

### *Type species*

*Umgazaniceras thieuloyi* sp. nov. Upper Valanginian, Umgazana, Transkei, southern Africa.

### *Etymology*

From the Umgazana River, the type locality.

### *Diagnosis*

Bochianitids with well-developed dorsolateral and ventrolateral clavi linked by simple or looped ribs and striae with intercalated ribs and striae between. Sutures rather simple for the subfamily.

*Umgazaniceras thieuloyi* sp. nov.

Figs 1-2, 3A-D, 4-5

### *Holotype*

SAM-PCT5702 in the South African Museum, Cape Town. From the Umgazana River, Transkei, southern Africa. Umgazana Formation, Upper Valanginian.

### *Paratypes*

SAM-PCT5695-5701, 5703-5, 5709-5710 from the same locality and horizon as above.

### *Etymology*

The species is named for Dr J. P. Thieuloy of Grenoble, who gave the authors much valuable advice in connection with this work.

### *Diagnosis*

As for genus.

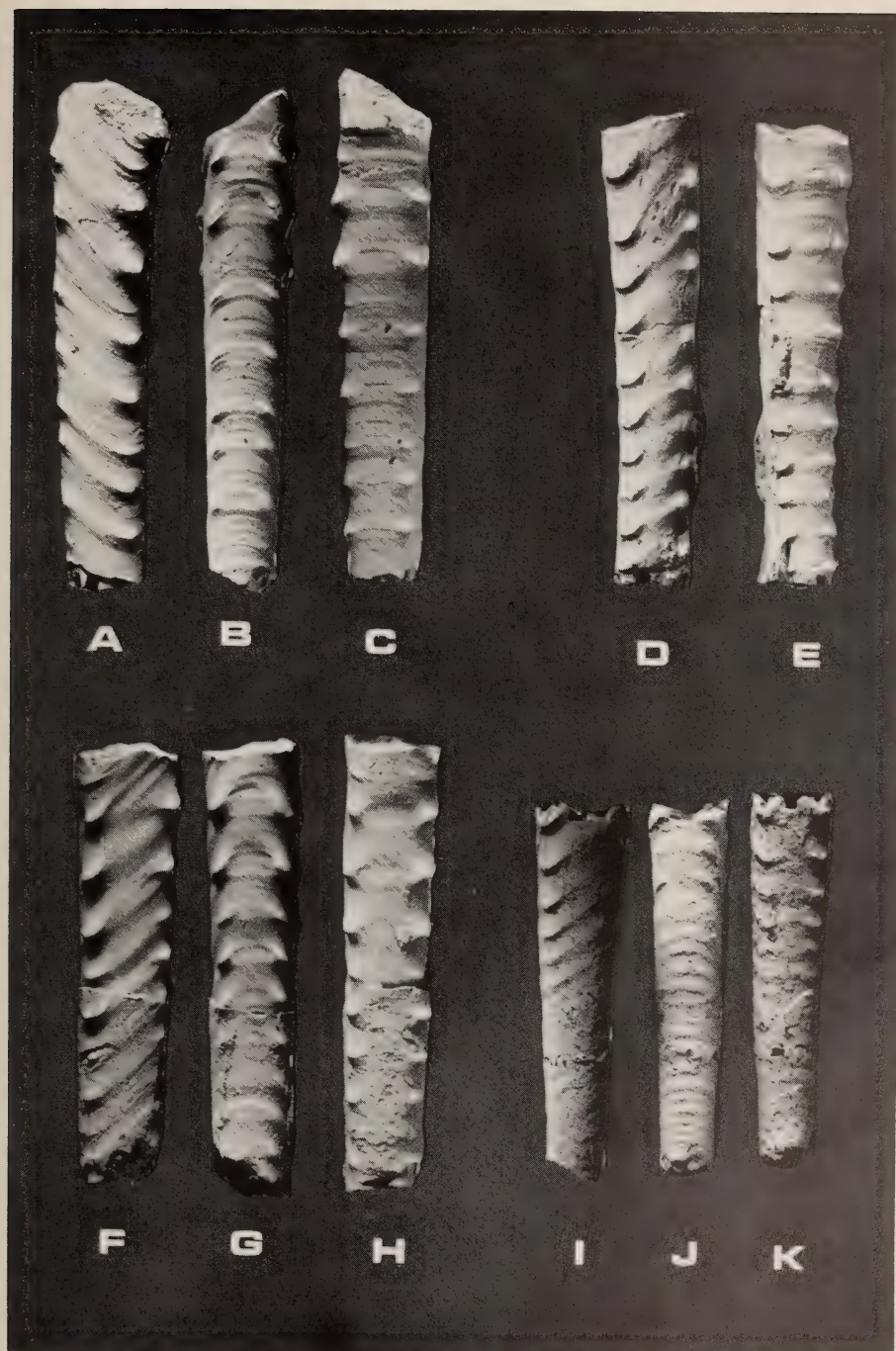


Fig. 1. *Umgazanicerás thieuloyi* gen. et sp. nov.

A-C. Holotype, SAM-PCT5702, lateral, ventral and dorsal views.  $\times 3$ . D-E. Paratype SAM-PCT5700, lateral and dorsal views.  $\times 3$ . F-H. Paratype SAM-PCT5704, lateral, ventral and dorsal views.  $\times 3, 1$ . I-K. Paratype SAM-PCT5709, lateral, ventral and dorsal views.  $\times 4, 6$ .



### Description

The shell is small, probably not exceeding 150 mm in length in the present material. The whorl section in the early stages of growth is ovoid, higher than wide (Fig. 2A), but eventually becomes subtriangular in intercostal section with a rounded venter and a flattened dorsum (Fig. 5). In some specimens, however, such as SAM-PCT5696 (Fig. 3A-C), the whorl section remains rounded up to large diameters.

At the very smallest diameter preserved, 1.5 mm (Fig. 1I-K), the flanks and dorsum appear devoid of ornament, whilst the venter bears faint convex striae. With increasing diameter, small auricular clavi appear at the dorso-lateral shoulder, together with smaller clavi situated at the inner ventrolateral shoulder and directed obliquely inwards in an apertural direction. Weak, prorsiradiate lateral striae connect the dorsal and ventral clavi across the flanks, dorsum and venter.

The remaining specimens are all adult. Ornament is very variable, but basically follows the following pattern: the dorsal clavi are auricular, situated at the dorsolateral shoulder and may protrude laterally to a considerable extent. They are connected over the dorsum by looped ribs. On the flanks the ventral part of the dorsal clavi merge rapidly into prorsiradiate, narrow and often poorly defined ribs, which in turn connect to the ventral clavi situated at the inner ventrolateral edge. The ventral clavi point obliquely inwards in an apertural direction, as in the juvenile stage. The abapical parts of the clavi are connected across the venter by forwardly curved, low folds, and the apical ends by straight to concave folds, thus forming a distinct, looped pattern over the venter.

Apart from the clavi and connecting ribs, fine intercalatory striae may occur, as in the holotype (Fig. 1A-C), and riblets may also appear as a series of bundled striae (Figs 1F-H, 3A-C). In the majority of specimens the ornament in the adult stage is prominent (Fig. 2B-D, H-L). One of the specimens, SAM-PCT 5696 (Fig. 3A-C), has similar, but very much weakened ornament at comparable size, and retains a rounded whorl section.

Specimen SAM-PCT 5695 (Fig. 3D) has the aperture preserved, with a ventral hood ornamented by fine striae.

The suture is relatively simple with a very small umbilical lobe (U), trifid lateral (L) and internal (I) lobes and bifid saddles (Fig. 4).

### Discussion

The presence of distinct tubercles distinguishes *Umgazanicerias thieuloyi* from all other bochianitids, and it occupies a unique position within the subfamily Bochianitinae.

The simplicity of the sutures and small umbilical lobe (U) are reminiscent of *Baculina rouyana* (d'Orbigny), but, as Wiedmann (1962) has successfully shown, generic separation based on sutural complexity alone is difficult to maintain.

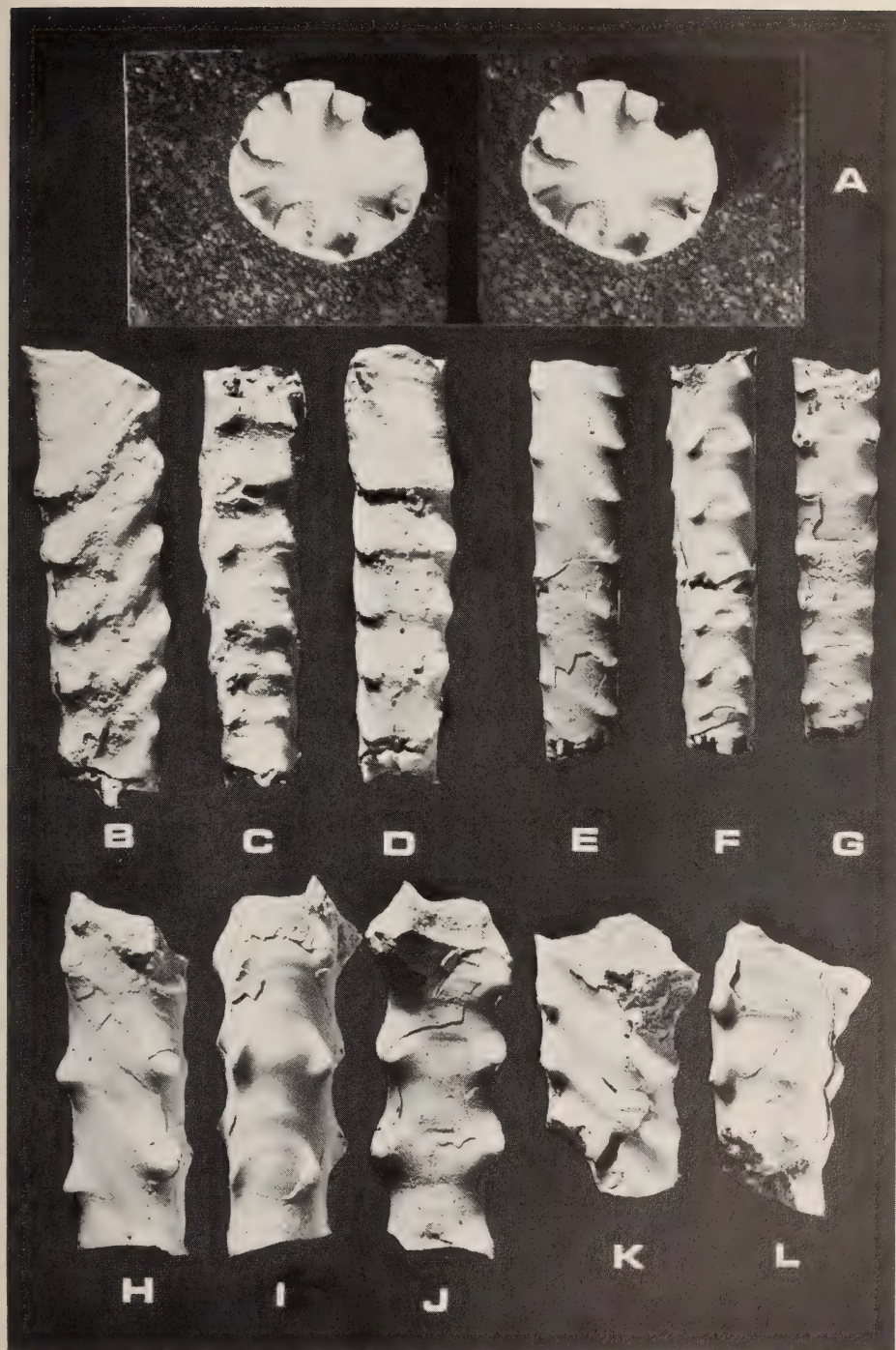


Fig. 2. *Umgazaniceras thieuloyi* gen. et sp. nov.

A. Paratype SAM-PCT5706, view of septal face, stereopair. B-D. Paratype SAM-PCT5706, lateral, ventral and dorsal views.  $\times 2,5$ . E-G. Paratype SAM-PCT5703, lateral, ventral and dorsal views.  $\times 3,1$ . H-J. Paratype SAM-PCT5701, lateral, ventral and dorsal views.  $\times 2,6$ . K-L. Paratype SAM-PCT5698, lateral and ventral views.  $\times 2,7$ .



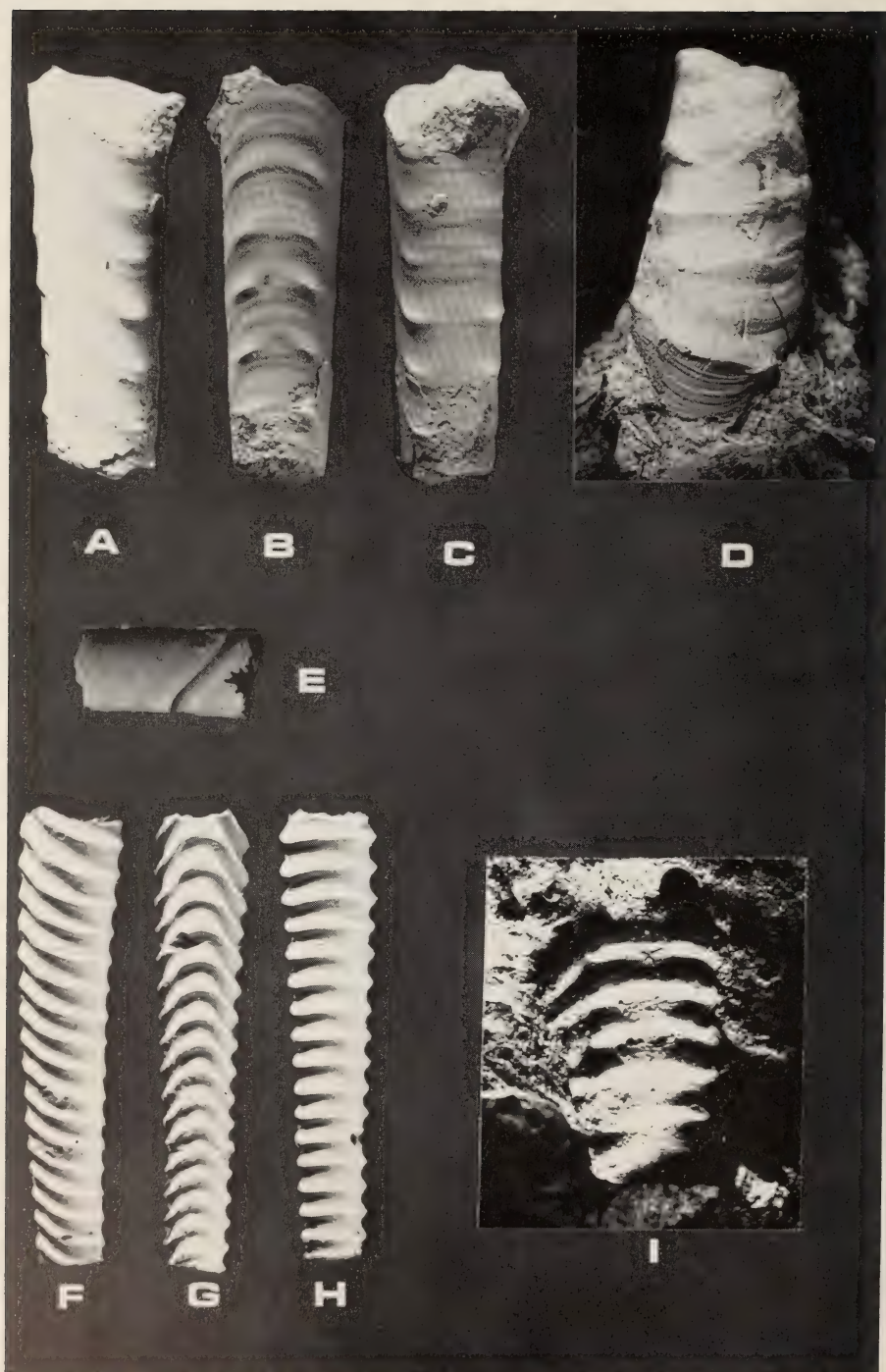


Fig. 3. A-C. *Umgazaniceras thieuloyi* gen. et sp. nov. Paratype, SAM-PCT5696, lateral, ventral and dorsal views.  $\times 2,1$ .

D. *Umgazaniceras thieuloyi* gen. et sp. nov. Paratype, SAM-PCT5695. Specimen with part of hooded aperture preserved.  $\times 2,5$ .

E. *Bochianites* cf. *renevieri* (Ooster, 1860). SAM-PCT5706.  $\times 5$ .

F-H. *Bochianites africanus* (Tate) SAM-PCU5706, figured for comparison.  $\times 1$ .

I. *Neohoploceras* sp. SAM-PCT5707.  $\times 3$  approx.



Fig. 4. *Umgazaniceras thieuloyi* gen. et sp. nov. Suture line.

A specimen of the common Uitenhage form, *Bochianites africanus* (Tate, 1867) is illustrated for comparison as Figure 3F–H. The only other known South African bochianitid, *B. glaber* Kitchin (1908: 181, pl. 8 (figs 20–21)), is completely smooth, but is difficult to interpret, being monotypic and immature.

#### Genus *Bochianites* Lory, 1898

*Bochianites* cf. *renevieri* (Ooster, 1860)

Fig. 3E

Compare:

*Baculites renevieri* Ooster, 1860: 91, pl. 60 (figs 4–5)

#### Material

One fragment, SAM-PCT5706 in the South African Museum.

#### Description and discussion

The single septate fragment differs from the remaining material in the presence of a strong constriction and lack of ornament. It strongly recalls *Bochianites renevieri* from the Upper Valanginian of Merligen, Switzerland, and the authors compare it tentatively to this species.

Other comparable *Bochianites* species with distinct constrictions may be *B. weteringi* Boehm (1904: 26, pl. 2 (fig. 5a–b), text-fig. 3); *B. versteeghi* Boehm (1904: 27, pl. 2 (fig. 6a–c), text-fig. 4); and *B. goubechensis* Mandov (1971: 97, pl. 3 (figs 1–9)). The latter two species, however, both have relatively strong ornament as compared to the Umgazana specimen. *B. weteringi* is very similar, but difficult to interpret, being based on incomplete material.

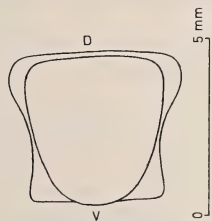


Fig. 5. *Umgazaniceras thieuloyi* gen. et sp. nov. Whorl section.



Family **Berriasellidae** Spath, 1922

Subfamily Neocomitidae Spath, 1924

Genus *Neohoploceras* Spath, 1939

*Neohoploceras* sp. indet.

Fig. 3I

### Material

One fragment only, SAM-PCT5707, in the South African Museum.

### Description and discussion

This small fragment of the venter of a strongly ribbed, normally coiled ammonite with well-developed ventral tubercles, appears to be a *Neohoploceras*, perhaps to be compared with the Uitenhage species *N. subanceps* (Tate) (1867: 150, pl. 7 (fig. 3a-b); Spath 1930: 151, pl. 13 (fig. 4a-c)). J. P. Thieuloy has drawn the authors' attention to the straight and sublinear ribbing on the venter, which appears to be a significant feature of this genus.

### ACKNOWLEDGEMENTS

We are grateful to Mr I. R. McLachlan (SOEKOR, Johannesburg) for putting this material at our disposal, and to Dr J. P. Thieuloy (Grenoble) for providing much useful information and discussion. Thanks are due to Mr N. Eden (South African Museum) for the photography of the specimens.

### REFERENCES

- BOEHM, G. 1904. Beiträge zur Geologie von Niederländisch-Indien. Die Südküsten der Sula-Inseln Taliabu und Mangoli. 1. Grenzsichten zwischen Jura und Kreide. *Palaeontographica* suppl. 4: 11-46.
- COOPER, M. R. 1974. The Cretaceous stratigraphy of South-Central Africa. *Ann. S. Afr. Mus.* 66: 81-107.
- DU TOIT, A. L. 1912. Geological Survey of part of the Transkei. *Ann. Rep. Comm. Cape of Good Hope* (for 1911): 87-109.
- DU TOIT, A. L. 1920. *The geology of Pondoland and portions of Alfred and lower Umzimkulu Counties, Natal: Explanation of Cape Sheet 28 (Pondoland)*. Pretoria: Geological Survey of South Africa.
- DU TOIT, A. L. 1954. *Geology of South Africa*. 3rd ed. London: Oliver & Boyd.
- HAUGHTON, S. H. 1969. *Geological History of Southern Africa*. Johannesburg: Geological Society of South Africa.
- KITCHIN, F. L. 1908. The Invertebrate Fauna and Palaeontological Relations of the Uitenhage Series. *Ann. S. Afr. Mus.* 7: 3-250.
- LORY, P. 1898. Le Crétacé inférieur du Dévoluy et des régions voisines. *Bull. Soc. géol. Fr.* 26: 132-138.
- MANDOV, G. 1971. Représentants du genre *Bochianites* Lory, 1898 (Ammonoidea) dans les dépôts du Crétacé inférieur en Bulgarie. *Izv. Geol. Inst. Bulgar. Akad. Nauk, Ser. Paleont.* 20: 91-107.
- MCLACHLAN, I. R., McMILLAN, I. K. & BRENNER, P. 1976. Micropalaeontological study of the Cretaceous beds at Mbotyi and Mngazana, Transkei, South Africa. *Trans. geol. Soc. S. Afr.* 79: 321-340.
- OOSTER, W. A. 1860. *Pétrifications remarquables des Alpes Suisses. Catalogue des Céphalopodes Fossiles des Alpes Suisses avec la description et les figures des espèces remarquables. IV*. Genève: Imp. H. Georg.

- ROGERS, A. W. & DU TOIT, A. L. 1909. *An introduction to the geology of the Cape Colony*. London: Longmans, Green & Co.
- SPATH, L. F. 1922. On Cretaceous Ammonoidea from Angola collected by Prof. J. W. Gregory, DSc, F.R.S. *Trans. R. Soc. Edinburgh* **53**: 91-160.
- SPATH, L. F. 1924. On ammonites of the Speeton Clay and the subdivisions of the Neocomian. *Geol. Mag.* **61**: 73-89.
- SPATH, L. F. 1930. On the Cephalopoda of the Uitenhage Beds. *Ann. S. Afr. Mus.* **28**: 131-157.
- SPATH, L. F. 1939. The Cephalopoda of the Neocomian Belemnite Beds of the Salt Range. *Mem. geol. Surv. India, Palaeont. indica*, n.s., **25**: 1-154.
- TATE, R. 1867. On some secondary fossils from South Africa. *Q. Jl geol. Soc. Lond.* **23**: 139-174.
- TRUSWELL, J. F. 1967. A critical review of stratigraphic terminology as applied in South Africa. *Trans. geol. Soc. S. Afr.* **70**: 81-116.
- WIEDMANN, J. 1962. Unterkreide-ammoniten von Mallorca. 1. Lieferung: Lytoceratina, Aptychi. *Abh. math.-naturw. Kl. Akad. Wiss. Mainz Jhrg.* **1961** (1): 1-148.



6. SYSTEMATIC papers must conform to the *International code of zoological nomenclature* (particularly Articles 22 and 51).

Names of new taxa, combinations, synonyms, etc., when used for the first time, must be followed by the appropriate Latin (not English) abbreviation, e.g. gen. nov., sp. nov., comb. nov., syn. nov., etc.

An author's name when cited must follow the name of the taxon without intervening punctuation and not be abbreviated; if the year is added, a comma must separate author's name and year. The author's name (and date, if cited) must be placed in parentheses if a species or subspecies is transferred from its original genus. The name of a subsequent user of a scientific name must be separated from the scientific name by a colon.

Synonymy arrangement should be according to chronology of names, i.e. all published scientific names by which the species previously has been designated are listed in chronological order, with all references to that name following in chronological order, e.g.:

Family Nuculanidae

*Nuculana (Lembulus) bicuspidata* (Gould, 1845)

Figs 14–15A

*Nucula (Leda) bicuspidata* Gould, 1845: 37.

*Leda plicifera* A. Adams, 1856: 50.

*Laeda bicuspidata* Hanley, 1859: 118, pl. 228 (fig. 73). Sowerby, 1871: pl. 2 (fig. 8a–b).

*Nucula largillierti* Philippi, 1861: 87.

*Leda bicuspidata*: Nicklès, 1950: 163, fig. 301; 1955: 110. Barnard, 1964: 234, figs 8–9.

Note punctuation in the above example:

comma separates author's name and year

semicolon separates more than one reference by the same author

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*Holotype*

SAM-A13535 in the South African Museum, Cape Town. Adult female from mid-tide region, King's Beach Port Elizabeth (33°51'S 25°39'E), collected by A. Smith, 15 January 1973.

Note standard form of writing South African Museum registration numbers and date.

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e.g. '... the Figure depicting *C. namacolus* ...'; '... in *C. namacolus* (Fig. 10) ...'
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- (b) *Abstract* of not more than 200 words, intelligible to the reader without reference to the text
- (c) *Table of contents* giving hierarchy of headings and subheadings
- (d) *Introduction*
- (e) *Subject-matter* of the paper, divided into sections to correspond with those given in table of contents
- (f) *Summary*, if paper is lengthy
- (g) *Acknowledgements*
- (h) *References*
- (i) *Abbreviations*, where these are numerous

3. MANUSCRIPT, to be submitted in triplicate, should be typewritten and neat, double spaced with 2.5 cm margins all round. First lines of paragraphs should be indented. Tables and a list of legends for illustrations should be typed separately, their positions indicated in the text. All pages should be numbered consecutively.

Major headings of the paper are centred capitals; first subheadings are shouldered small capitals; second subheadings are shouldered italics; third subheadings are indented, shouldered italics. Further subdivisions should be avoided, as also enumeration (never roman numerals) of headings and abbreviations.

Footnotes should be avoided unless they are short and essential.

Only generic and specific names should be underlined to indicate italics; all other marking up should be left to editor and publisher.

4. ILLUSTRATIONS should be reducible to a size not exceeding  $12 \times 18$  cm (19 cm including legend); the reduction or enlargement required should be indicated; originals larger than  $35 \times 47$  cm should not be submitted; photographs should be rectangular in shape and final size. A metric scale should appear with all illustrations, otherwise magnification or reduction should be given in the legend; if the latter, then the final reduction or enlargement should be taken into consideration.

All illustrations, whether line drawings or photographs, should be termed figures (plates are not printed; half-tones will appear in their proper place in the text) and numbered in a single series. Items of composite figures should be designated by capital letters; lettering of figures is not set in type and should be in lower-case letters.

The number of the figure should be lightly marked in pencil on the back of each illustration.

5. REFERENCES cited in text and synonymies should all be included in the list at the end of the paper, using the Harvard System (*ibid.*, *idem*, *loc. cit.*, *op. cit.* are not acceptable):

(a) Author's name and year of publication given in text, e.g.:

- 'Smith (1969) describes ...'
- 'Smith (1969: 36, fig. 16) describes ...'
- 'As described (Smith 1969a, 1969b; Jones 1971)'
- 'As described (Haughton & Broom 1927) ...'
- 'As described (Haughton *et al.* 1927) ...'

*Note:* no comma separating name and year

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(b) Full references at the end of the paper, arranged alphabetically by names, chronologically within each name, with suffixes *a*, *b*, etc. to the year for more than one paper by the same author in that year, e.g. Smith (1969a, 1969b) and not Smith (1969, 1969a).

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KOHN, A. J. 1960b. Spawning behaviour, egg masses and larval development in *Conus* from the Indian Ocean. *Bull. Bingham oceanogr. Coll.* 17 (4): 1-51.

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(continued inside back cover)

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A NEW SPECIES OF  
*MYOPHORELLA* (BIVALVIA, TRIGONIIDAE) FROM  
THE SUNDAY'S RIVER FORMATION,  
SOUTH AFRICA

By  
MICHAEL R. COOPER

Cape Town Kaapstad



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FROM THE SUNDAY'S RIVER FORMATION, SOUTH AFRICA

By

MICHAEL R. COOPER

*Department of Geology, University of Oxford\**

(With 2 figures)

[MS. accepted 22 December 1978]

ABSTRACT

The genus *Myophorella* Crickmay is recorded for the first time from southern Africa with the description of *M. oosthuizeni* sp. nov. from Upper Valanginian strata of the Sunday's River Formation.

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INTRODUCTION

The family Trigoniidae comprises a long-ranging group of bivalves which first appeared in the Upper Triassic and are today represented by a solitary genus, *Neotrigonia*, which is restricted to subtropical to temperate waters off the coast of Australia.

Although some workers have subdivided the family into a number of subfamilies (Van Hoepen 1929; Skwarko 1963) this concept has been rejected by other workers (Cox 1969). The great diversity of forms within the Trigoniidae suggests that the family may usefully be split into a number of subfamilies. However, the latter categories are typically phylogenetic concepts and, at present, very little evolutionary data have been presented to justify many of the suggested subdivisions.

The genus *Myophorella* Bayle (*in* Bayle & Zeiller 1878) first appeared in the Middle Jurassic (middle Lias) and finally became extinct during the Lower Cretaceous (Aptian), attaining its acme during the late Jurassic, at which time it attained a virtually cosmopolitan distribution.

SYSTEMATICS

Order TRIGONIOIDA Dall, 1889

Superfamily TRIGONIACEA Lamarck, 1819

Family **Trigoniidae** Lamarck, 1819

Genus *Myophorella* Bayle, 1878

*Type species*

*Trigonia nodulosa* Lamarck, 1801; by subsequent designation of Crickmay (1932).

\* Present address: Queen Victoria Museum, Salisbury, Rhodesia.

### Discussion

Cox (1969) included *Myophorella* (*Promyophorella*), *M. (Haidaia)*, *Scaphotrigonia*, *Clavotrigonia* and *Clavitrighonia* as junior subjective synonyms of *Myophorella* s.s., whilst *Pseudomyophorella* is considered a subgenus, distinguished by possessing radial ribs on the area. *Scaphitrigon* is based on a publisher's error of the genus *Scaphogonia*.

### *Myophorella (Myophorella) oosthuizeni* sp. nov.

Fig. 1

### Material

Five specimens in the collection of Mr R. Oosthuizen of Zwartskraal, Prince Albert.

### Holotype

RO 300 (SAM-PCU5941) is designated as holotype, the remaining specimens are paratypes.

### Etymology

For Mr Roy Oosthuizen, whose keen interest and diligent collecting has contributed greatly towards an understanding of the fossiliferous deposits of southern Africa.

### Type locality

Zwartkops brick quarry, Port Elizabeth, in the sediments of the Sunday's River Formation, and thus of late Valanginian age.

### Diagnosis

A late Valanginian species of *Myophorella* characterized by an unornamented escutcheon; regular, large, obliquely clavate tubercles on the inner and marginal carinae; fine, transverse liration of the area; the absence of tubercles defining the median longitudinal furrow of the area; flank costae which arise either at right angles to, or directed posteriorly so as to form an acute angle with, the marginal carina; the anterior set of costae are strongly curved, so as to terminate mostly along the anterior and anteroventral margin of the commissure; there is a break in the regularity of tuberculation of those costae terminating along the anteroventral commissure; the flanks are finely lirate.

### Description

The shell is small, trigonally ovate, with the valves moderately inflated, and somewhat produced posteriorly. The umbones are moderately incurved and situated about one-fifth of the shell length from the anterior margin. The escutcheon is large, lanceolate, and extends almost the entire length of the dorsal margin of the shell. The inner carina is marked by regular, large, obliquely clavate tubercles increasing in size posteriorly, as well as converging posteriorly.

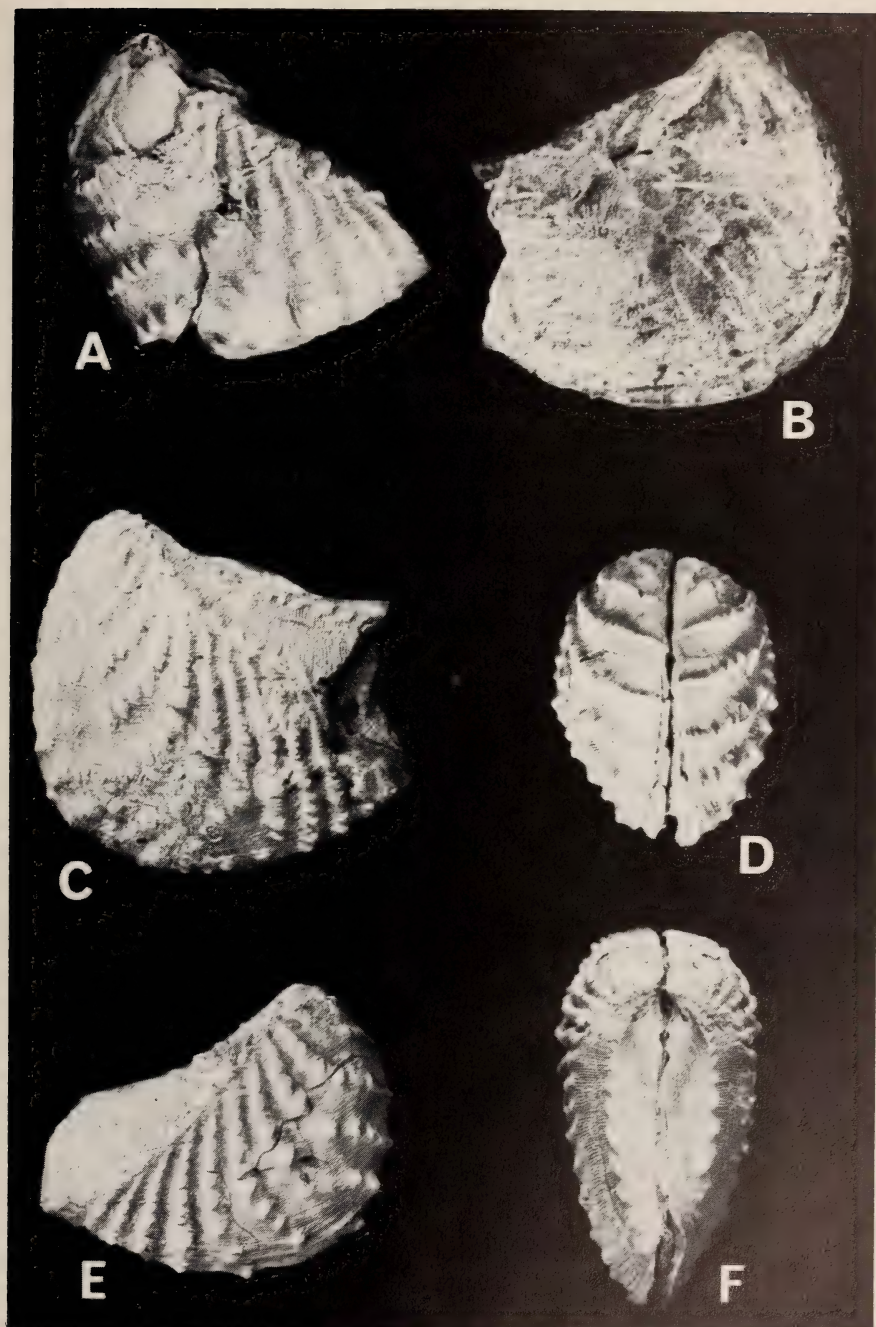


Fig. 1. *Myophorella* (*Myophorella*) *oosthuizeni* sp. nov.

A. Left valve of paratype. B-C. Interior and exterior views of left valve of paratype. D-F. Anterior, lateral and dorsal views of the holotype, R0300 (SAM-PCU5941).  $\times 1,5$ .



The area is trigonal, rather narrow, and ornamented by uniform, fine lirae which show no sign of increasing in strength posteriorly. The area is divided by a fine, but distinct, median longitudinal furrow which is situated much closer to the inner carina than to the marginal carina. As with the inner carina, the marginal carina is marked by a regular row of obliquely clavate tubercles which, however, converge anteriorly. The posterior margin of the area is abruptly truncate, slightly convex, and meets the dorsal margin at an angle of about  $110^\circ$ . Each tubercle of the marginal carina gives rise to rather weakly-developed flank ribs which, on the anterior half of the valves, curve strongly forwards so as to terminate mostly along the anterior and anteroventral margins on the commissure. From the marginal carina, the ribs are directed posteriorly, only slightly so in the nepionic growth stages but strongly so in maturity, when they meet the marginal carina at an angle of about  $30^\circ$ . The posterior set of ribs is almost straight. All the ribs are ornamented with prominent tubercles which are, in general, regularly spaced, although those ribs terminating along the anteroventral commissure show a distinct break in tuberculation, as well as some irregularities in their positioning. The entire surface of the flanks is ornamented by prominent, fine, concentric lirae which follow the growth lines, and are continuous with the lirae on the area.

#### Discussion

Amongst described species of *Myophorella*, *M. oosthuizeni* sp. nov. undoubtedly shows closest relationships with *M. alexandra* Willey (1957: 77 (fig. 2a-c)) from the Berriasian of Antarctica. *Myophorella alexandra* differs in having finely tuberculate inner and marginal carinae, and in that the transverse lirae of the area strengthen posteriorly. Moreover, in maturity, the tubercles of the marginal and inner carinae of *M. alexandra* become obsolete and are replaced by lamella protuberances. The differences are not great but, because of the different ages of the few known specimens of each species, are considered to be of specific importance.

*Myophorella dekaiboda* Kobayshi & Tamura (1955: 95, pl. 6 (figs 6-9)) from the Jurassic of Japan somewhat resembles the present species, but is based upon poorly preserved internal moulds and composite internal moulds which are not directly comparable with *M. oosthuizeni* sp. nov. The vastly different ages and wide geographic separation suggests that they are specifically distinct.

Cox (1965) has recently described two species of *Myophorella* from the Kimmeridgian of Tanzania, *M. quennelli* Cox (1965: 79, p. 12 (fig. 1)) and *M. kiwawaensis* Cox (1965: 80, pl. 12 (fig. 2)), but neither warrants comparison with the present form.

*Myophorella kutchensis* (Kitchin) (1903: 84, pl. 7 (fig 7-9)) (Fig. 2) resembles the present species, but is more ovate in outline and not produced posteriorly as much as *M. oosthuizeni* sp. nov. Moreover, the area is much wider in Kitchin's species, as well as being more coarsely lirate, whilst the tubercles of the marginal carina do not appear to be obliquely clavate as in *M. oosthuizeni*.



Fig. 2. *Myophorella (Myophorella) kutchensis* (Kitchin). The syntypes. After Kitchin (1903).  
 $\times 1$ .

*Myophorella rupellensis* (d'Orbigny) (Lycett 1872: 28, pl. 8 (fig. 4)), *M. ingens* (Lycett) (1872: 24, pl. 8 (figs 1-3)), and *M. corallina* (d'Orbigny) (Lycett 1872: 45, pl. 3 (figs 7-9, 11)) are all Jurassic species which differ from *M. oosthuizeni* sp. nov. in lacking a tuberculate marginal carina and in that the flank ribs are directed anteriorly from the marginal carina.

*Myophorella mermodi* (Chavan) (1952: 50, pl. 3 (fig. 5)) has a more ovate outline than *M. oosthuizeni*, with flank ribs that are directed anteriorly from the marginal carina and tubercles on the area, marking the median longitudinal furrow.

*Myophorella norberti* (Chavan) (= *Trigonia perlata* Lycett (non Agassiz) 1872: 22, pl. 11 (fig. 3 only)) differs from the present species in the irregular nature of the flank ribs and tubercles, and having finely tuberculate inner and marginal carinae, as well as a raised rib marking the median longitudinal furrow.

*Myophorella clavellata* (J. Sowerby) (Lycett 1872: 18, pl. 1 (figs 1-2)), *M. perlata* (Agassiz) (Lycett 1872: 22, pl. 3 (figs 1-3)) and *M. juddiana* (Lycett) (1872: 25, pl. 2 (fig. 6), pl. 4 (figs 5, 7)) are all Jurassic species which have a less curved anterior margin to the shell, a subquadratic outline, and finely tuberculate carinae (as well as one marking the median longitudinal furrow).

*Myophorella exotica* (Möricke) (1895: 49, pl. 1 (fig. 9), pl. 6 (fig. 9)) is a Bajocian species based upon composite internal moulds which may have

suffered slight distortion, and are thus difficult to compare. It differs, however, in having a finely tuberculate marginal carina.

*Myophorella australiana* Skwarko (1963: 38, pl. 5 (figs 8–11)) from the Aptian of Queensland differs from *M. oosthuizeni* sp. nov. in that the area and marginal carina are irregularly tuberculate, whilst most of the ribs are straight and terminate along the ventral commissure.

*Myophorella alina* (Contejean) (1859: 282, pl. 14 (figs 3–5)) is a Kimmeridgian species with a more coarsely ribbed area and tubercles lining the median longitudinal furrow, whilst the flank ribs are directed anteriorly from the marginal carina. The younger *M. bronni* (Agassiz) (1841: 18, pl. 5 (fig. 19)) differs from *M. oosthuizeni* in much the same features.

*Myophorella signata* (Agassiz) (1841: 18, pl. 3 (fig. 8), pl. 9 (fig. 5)) differs from *M. oosthuizeni* in having finely nodose carinae, including one marking the median longitudinal furrow.

*Myophorella goldfussi* (Agassiz) (1841: 24) (= *Lyrodon literatum* Goldfuss 1834: 200, pl. 136 (fig. 5 only)), like *M. oosthuizeni* has obliquely clavate tubercles lining the marginal carinae, but lacks the fine liration of the flanks seen in *M. oosthuizeni*, and also has tubercles lining the median longitudinal furrow.

*Myophorella polonica* (Lebküchner) (1933: 60, pl. 4 (fig. 5)) lacks the fine liration of the flanks seen in *M. oosthuizeni*, and also has coarser ribs on the area. *Myophorella trafalgarensis* (Warren) (1932: 18, pl. 3 (figs 5–6)) is a Callovian species which shows the same general features of *M. oosthuizeni*, especially in the nature of the flank ribs, but appears to lack tuberculate carinae.

#### Occurrence

*Myophorella oosthuizeni* is known only from the Upper Valanginian of South Africa.

#### SUMMARY

The new species *Myophorella oosthuizeni* from the late Valangian Sunday's River Formation provides the first record of this genus from southern Africa. It is most closely allied to *M. alexandra* Willey from the Berriasian of Antarctica.

#### ACKNOWLEDGEMENTS

Once again I wish to extend my best thanks to Mr R. Oosthuizen for making available to me the material in his collections.

#### REFERENCES

- AGASSIZ, L. 1841. *Mémoire sur les trigonies. Études critiques sur les mollusques fossiles*. Neuchâtel.
- BAYLE, E. & ZEILLER, R. 1878. *Explication de la carte géologique de la France*. Paris.
- CHAVAN, A. 1952. Les pélécytopes de sablès astartiens de Cordebugle (Calvados) *Schweiz. palaeont. Abh.* **69** (3): 1–132.
- CONTEJEAN, C. 1859. *Étude de l'étage Kimmeridien dans les environs de Montbeliard*. Paris.
- COX, L. R. 1965. Jurassic Bivalvia and Gastropoda from Tanganyika and Kenya. *Bull. Br. Mus. nat. Hist. (Geol.) Suppl.* **1**: 1–213.



- COX, L. R. 1969. Family Trigoniidae. In: MOORE, R. C. ed. *Treatise on invertebrate paleontology*. Part N (1), Mollusca 6, Bivalvia. Lawrence: Geological Society of America, University of Kansas Press.
- GOLDFUSS, A. 1826-40. *Petrefacta Germaniae tam ea quae in museo universitatis regiae borussiae Friedericiae Wilhelminae rhenanae servandur*. Dusseldorf.
- HOEPEN, E. C. N. VAN. 1929. Die krytfauna van Soeloeland. I. Trigoniidae. *Paleont. Navors. nas. Mus. Bloemfontein* 1 (1): 1-38.
- KITCHIN, F. L. 1903. The Jurassic fauna of Cutch. The Lamellibranchiata. Genus *Trigonia*. *Mem. geol. Surv. India Palaeont. indica* (9) 3 (2): 1-122.
- KOBAYASHI, T. & TAMURA, M. 1955. The Myophorellinae from North Japan. Studies on the Jurassic trigonians in Japan. Part IV. *Jap. J. Geol. Geogr.* 26: 89-104.
- LAMARCK, J. B. DE. 1801. *Système des animaux sans vertebres*. Paris.
- LEBKÜCHNER, R. 1933. Die Trigonien des süddeutschen Jura. *Palaeontographica* 77: 1-119.
- LYCETT, J. 1872-1879. A monograph of the British fossil Trigoniae. *Palaeont. Soc.* (Monogr.) 1872: 1-52, 1874: 53-92, 1875: 93-148, 1877: 149-204, 1879: 205-245.
- MÖRICKE, W. 1895. Versteinerungen des Lias und Unteröolith von Chile. *Neues Jb. Miner. Geol. Paläont. BeilBd.* 9: 1-100.
- SKWARKO, S. K. 1963. Australian Mesozoic trigoniids. *Bull. Bur. Miner. Resour. Geol. Geophys. Aust.* 67: 1-42.
- WARREN, P. S. 1932. A new pelecypod fauna from the Fernie Formation, Alberta. *Proc. Trans. R. Soc. Can.* (3) 26 (4): 1-36.
- WILLEY, L. E. 1975. Upper Jurassic and lowest Cretaceous Trigoniidae (Bivalvia) from south-eastern Alexander Island. *Bull. Br. Antarct. Surv.* 41-42: 77-85.









6. SYSTEMATIC papers must conform to the *International code of zoological nomenclature* (particularly Articles 22 and 51).

Names of new taxa, combinations, synonyms, etc., when used for the first time, must be followed by the appropriate Latin (not English) abbreviation, e.g. gen. nov., sp. nov., comb. nov., syn. nov., etc.

An author's name when cited must follow the name of the taxon without intervening punctuation and not be abbreviated; if the year is added, a comma must separate author's name and year. The author's name (and date, if cited) must be placed in parentheses if a species or subspecies is transferred from its original genus. The name of a subsequent user of a scientific name must be separated from the scientific name by a colon.

Synonymy arrangement should be according to chronology of names, i.e. all published scientific names by which the species previously has been designated are listed in chronological order, with all references to that name following in chronological order, e.g.:

Family Nuculanidae

*Nuculana (Lembulus) bicuspidata* (Gould, 1845)

Figs 14–15A

*Nucula (Leda) bicuspidata* Gould, 1845: 37.

*Leda plicifera* A. Adams, 1856: 50.

*Laeda bicuspidata* Hanley, 1859: 118, pl. 228 (fig. 73). Sowerby, 1871: pl. 2 (fig. 8a–b).

*Nucula largillierii* Philippi, 1861: 87.

*Leda bicuspidata*: Nickles, 1950: 163, fig. 301; 1955: 110. Barnard, 1964: 234, figs 8–9.

Note punctuation in the above example:

comma separates author's name and year

semicolon separates more than one reference by the same author

full stop separates references by different authors

figures of plates are enclosed in parentheses to distinguish them from text-figures

dash, not comma, separates consecutive numbers

Synonymy arrangement according to chronology of bibliographic references, whereby the year is placed in front of each entry, and the synonym repeated in full for each entry, is not acceptable.

In describing new species, one specimen must be designated as the holotype; other specimens mentioned in the original description are to be designated paratypes; additional material not regarded as paratypes should be listed separately. The complete data (registration number, depository, description of specimen, locality, collector, date) of the holotype and paratypes must be recorded, e.g.:

*Holotype*

SAM-A13535 in the South African Museum, Cape Town. Adult female from mid-tide region, King's Beach Port Elizabeth (33°51'S 25°39'E), collected by A. Smith, 15 January 1973.

Note standard form of writing South African Museum registration numbers and date.

## 7. SPECIAL HOUSE RULES

### *Capital initial letters*

- The Figures, Maps and Tables of the paper when referred to in the text  
e.g. '... the Figure depicting *C. namacolus* ...'; '... in *C. namacolus* (Fig. 10) ...'
- The prefixes of prefixed surnames in all languages, when used in the text, if not preceded by initials or full names  
e.g. Du Toit but A. L. du Toit; Von Huene but F. von Huene
- Scientific names, but not their vernacular derivatives  
e.g. Therocephalia, but therocephalian

*Punctuation* should be loose, omitting all not strictly necessary

*Reference to the author* should be expressed in the third person

*Roman numerals* should be converted to arabic, except when forming part of the title of a book or article, such as

'Revision of the Crustacea. Part VIII. The Amphipoda.'

*Specific name* must not stand alone, but be preceded by the generic name or its abbreviation to initial capital letter, provided the same generic name is used consecutively.

*Name of new genus or species* is not to be included in the title: it should be included in the abstract, counter to Recommendation 23 of the Code, to meet the requirements of Biological Abstracts.



MICHAEL R. COOPER

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*et al.* in text for more than two joint authors, but names of all authors given in list of references.

(b) Full references at the end of the paper, arranged alphabetically by names, chronologically within each name, with suffixes *a*, *b*, etc. to the year for more than one paper by the same author in that year, e.g. Smith (1969a, 1969b) and not Smith (1969, 1969a).

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KOHN, A. J. 1960a. Ecological notes on *Conus* (Mollusca: Gastropoda) in the Trincomalee region of Ceylon. *Ann. Mag. nat. Hist.* (13) 2: 309-320.  
KOHN, A. J. 1960b. Spawning behaviour, egg masses and larval development in *Conus* from the Indian Ocean. *Bull. Bingham oceanogr. Coll.* 17 (4): 1-51.  
THIELE, J. 1910. Mollusca: B. Polyplacophora, Gastropoda marina, Bivalvia. In: SCHULTZE, L. *Zoologische und anthropologische Ergebnisse einer Forschungsreise im westlichen und zentralen Süd-Afrika* 4: 269-270. Jena: Fischer. *Denkschr. med.-naturw. Ges. Jena* 16: 269-270.

(continued inside back cover)

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CRETACEOUS FAUNAS FROM ZULULAND AND  
NATAL, SOUTH AFRICA  
A NEW GENUS AND SPECIES OF  
TUBERCULATE DESMOCERATACEAN AMMONITE  
FROM THE MZINENE FORMATION (ALBIAN)

By  
WILLIAM JAMES KENNEDY  
CLAUDE WILLIAM WRIGHT  
&  
HERBERT CHRISTIAN KLINGER

Cape Town Kaapstad



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By

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(With 4 figures)

[MS. accepted 4 January 1979]

ABSTRACT

The low Middle Albian Mzinene Formation in its type area yields numerous specimens of *Umsinenoceras linguatuberculatum* gen. et sp. nov., previously identified as *Neosilesites* (Kennedy & Klinger, 1975) but probably a member of the Puzosiinae. It is closely related to *Feruglioceras* Leanza, 1967, and resembles various Marshallitinae (Kossmaticeratidae).

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INTRODUCTION

In a preliminary account of the stratigraphy and ammonite faunas of the Zululand Cretaceous, Kennedy & Klinger (1975) recorded in provisional lists from their division III of the Albian the genus '*Neosilesites*', associated with a diverse fauna indicating a low Middle Albian horizon. As a result of further collecting of well-preserved specimens, this material has been found to represent not a silesitid, but a new genus of Puzosiinae, allied to *Feruglioceras* Leanza, 1967, and an approximate homoeomorph of various Kossmaticeratids. The species is described below as *Umsinenoceras linguatuberculatum* gen. et sp. nov.

## SYSTEMATIC DESCRIPTION

Superfamily DESMOCERATACEAE Zittel, 1895

Family **Desmoceratidae** Zittel, 1895

Subfamily Puzosiinae Spath, 1922

Genus *Umsinenoceras* nov.*Type species**Umsinenoceras linguatuberculatum* gen. et sp. nov., low Middle Albian, Zululand.*Derivation of name*

Named after the Mzinene River, alternatively spelt Umsinene.

*Diagnosis*

Small, compressed, relatively evolute, with dense, fine, flexuous prorsiradiate ribs which may split across the ventrolateral shoulder. Venter flattened with fine striae only during middle growth stages. Constrictions frequent in middle and later growth, parallel with the ribs, prorsiradiate, interrupted over the siphuncle on internal moulds. Ventrolateral clavi irregularly developed in middle and later growth. Slight, sharp umbilical bullae sometimes present. Suture deeply incised, with bifid saddles, asymmetrically trifold L and retracted U.

*Occurrence*

Low Middle Albian of Zululand.

*Umsinenoceras linguatuberculatum* sp. nov.

Figs 1-4

*Holotype*

BMNH C81275, from the Mzinene Formation, Albian III, locality 35, cliff and stream sections extending over several hundred metres along the Mzinene approximately, 1 200 m NE of the farm Amatis, north of Hluhluwe, Zululand, 27°58'03"S 32°18'31"E. In the collections of the British Museum (Natural History).

*Paratypes*

BMNH C81276-81298 and SAS A1363, A1372, A1413-4, from the same horizon and locality, housed in the collections of the British Museum (Natural History), and the Geological Survey (Pretoria).

*Derivation of name*

Latin *lingua*-, tongue, and *tuberculatus* -um, tuberculate, in reference to the linguiform line of ribs and constrictions, combined with tubercles, on the venter.

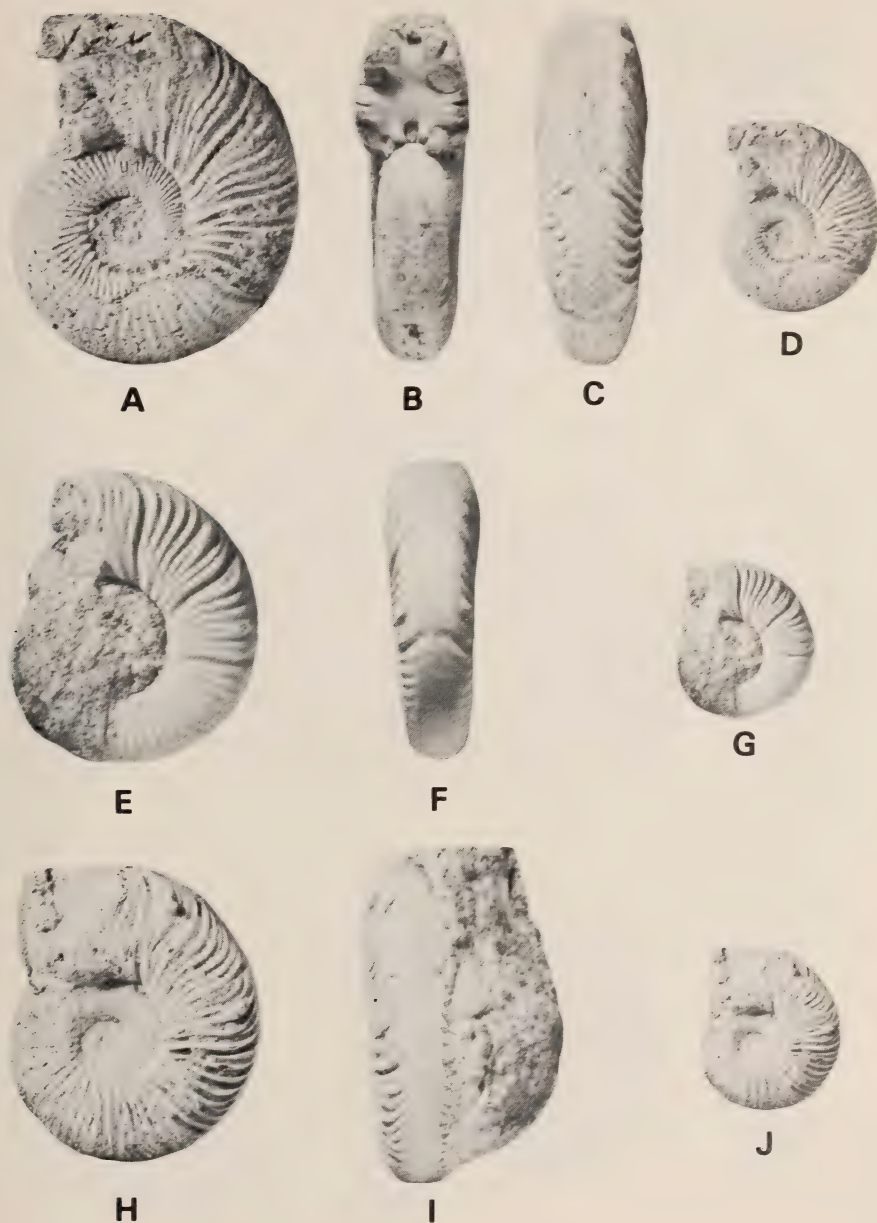


Fig. 1. *Umsinenoceras linguatuberculatum* gen. et sp. nov. A-D. Holotype BMNH C81275. E-G. Paratype C81283. H-J. Paratype C81282. A-C, E-F, H-I  $\times 2$ ; D, G, J  $\times 1$ .



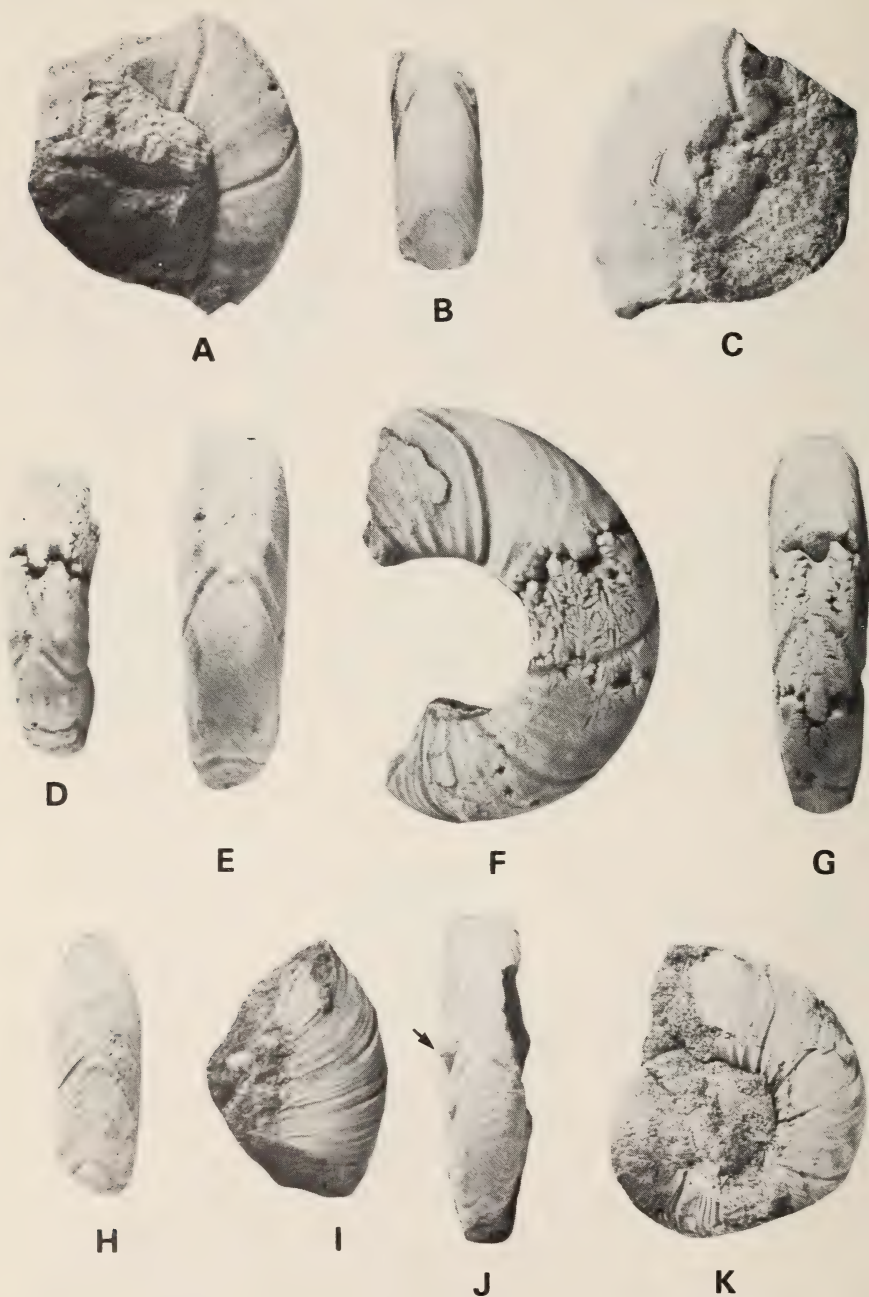


Fig. 2. *Umsinenoceras linguatuberculatum* gen. et sp. nov. A-C. Paratype BMNH C81279, a body chamber. D-G. Paratype BMNH 281277, adult phragmocone with part of body chamber. H-I. Paratype BMNH C81276, with preserved aperture. J-K. Paratype BMNH C81278, preserving shell and septate tubercle (arrowed).

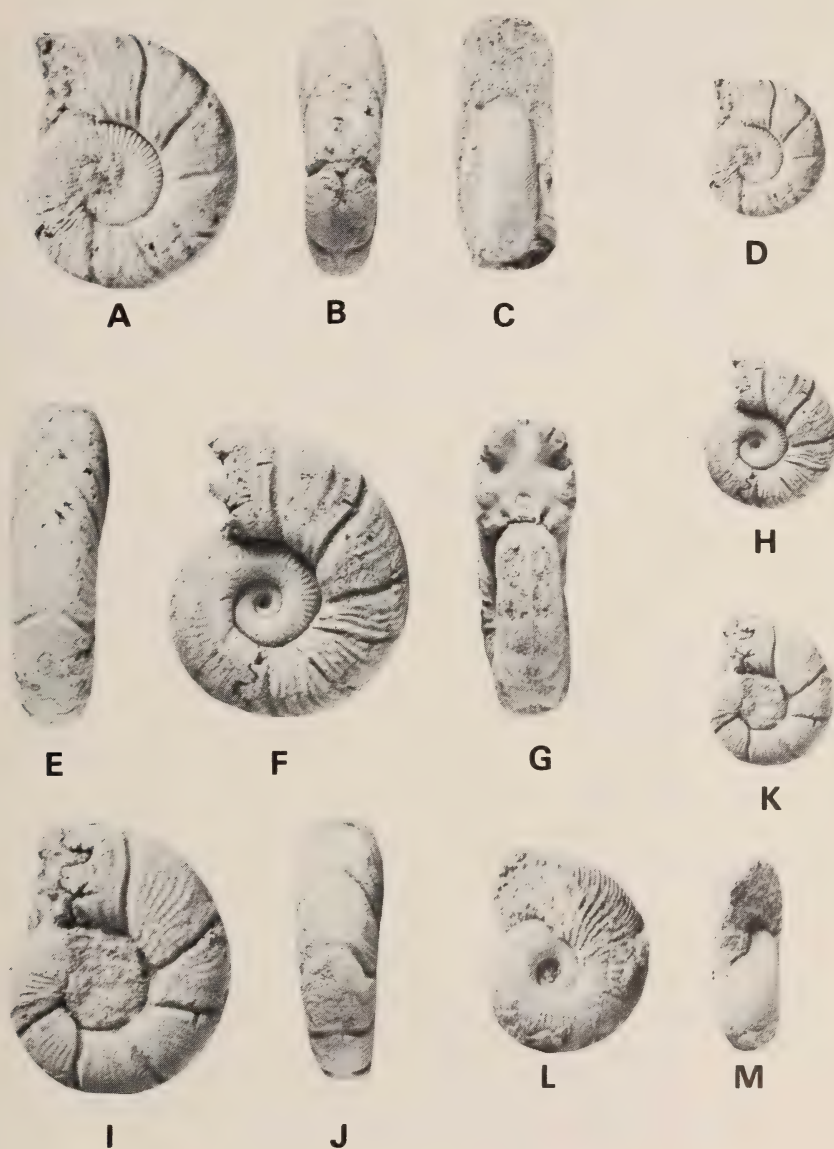


Fig. 3. *Umsinenoceras linguatuberculatum* gen. et sp. nov. A-B, D. Paratype BMNH C81285. C. Paratype BMNH C81287. E-H. Paratype BMNH C81281. I-K. Paratype BMNH C81284. L-M. Paratype BMNH C81288. A-C, E-G, I-J, L-M  $\times 2$ ; D, H, K  $\times 1$ .

*Dimensions*

All dimensions are in millimetres. D = diameter, Wb = whorl breadth, Wh = whorl height, U = umbilical diameter.

Figures in parentheses are dimensions expressed as percentages of the total diameter.

			D	Wb	Wh	Wb:Wh	U
BMNH C81277	..	..	46,5 (100)	11,2 (24)	16,8 (36)	0,67	18,6 (40)
Holotype							
BMNH C81275	..	..	26,4 (100)	8,0 (30)	9,3 (35)	0,86	9,2 (35)
BMNH C81280	..	..	24,8 (100)	7,2 (29)	8,4 (34)	0,86	8,5 (34)
BMNH C81281	..	..	22,2 (100)	7,2 (32)	7,4 (33)	0,97	8,3 (37)
BMNH C81285	..	..	20,0 (100)	6,3 (32)	6,4 (32)	0,98	7,8 (39)



Fig. 4. *Umsinenoceras linguatuberculatum* gen. et sp. nov. A. External suture of paratype BMNH C81277. B. Paratype C81280. Both  $\times 6$ .

### Description

The earliest stages of development are revealed by BMNH C81288; these show the coiling to be relatively involute up to a diameter of 6 mm, with a shallow umbilicus, a low, rounded umbilical wall and a broadly rounded whorl section. Internal moulds appear smooth but the shell, where preserved, bears fine, dense, flexuous ribs. By a diameter of 10 mm the coiling is more evolute. The umbilicus now comprises 25 per cent of the diameter and is shallow, with a low, rounded wall. The whorl section is slightly depressed with an abruptly rounded umbilical shoulder, flattened inner flanks, convergent outer flanks, an abruptly and narrowly rounded ventrolateral shoulder and a flattened venter. Ornament consists of fine, dense, prorsiradiate ribs, typically 60–70 per whorl; these arise at the umbilical seam, strengthen across the wall and in some cases bifurcate at the umbilical shoulder. They sweep forwards across the inner flank, and are feebly convex, sweeping backwards across the mid-flank. The ribs either split in pairs, or a short intercalated rib appears on the outer third of the flanks, where all ribs are concave, sweeping forwards across the shoulders. The ribs disappear on the flattened venter, where the shell bears only faint delicate striae, projected in a tongue-like extension. The ribs are strong and wire-like on the shell but the ornament of the internal moulds is very feeble.

Constrictions first appear at a diameter of 13 to 16 mm. On the shell these are deep, narrow, flexuous and prorsiradiate and are both followed and preceded by a strengthened rib. On the mould the constrictions are broader and pass across the venter with little diminution in depth, being projected parallel to the growth striae. The spacing of constrictions is variable; in BMNH C81280 there are six in a half whorl at a diameter of 24 mm; in BMNH C81284 the same number occupy a whole whorl.

As size increases, irregularly spaced ventrolateral nodes appear. On moulds they are blunt and clavate; where shell is present (e.g. BMNH C81278) it is clear that the node represents the base only of a tiny septate, finger-like, round-topped horn. These clavi commonly develop on a thickened rib or two or three of the long ribs may link with them.

Three specimens, BMNH C81276–8, show the compressed, flat-sided adult body chamber. Here the ribs and striae are irregularly developed, prorsiradiate and strongly concave rather than flexuous, the venter becomes somewhat rounded, and is crossed by occasional ribs and constrictions which project forwards in a long, narrow tongue.

The suture line (Fig. 4) is deeply incised, with a large, asymmetrically bifid E/L, deep L asymmetrically trifid, LU<sub>2</sub> asymmetrically bifid, and U distinctly retracted.

### DISCUSSION

There are some similarities between *Umsinenoceras* and late members of the Silesitidae such as *Neosilesites* Breistroffer and *Parasilesites* Imlay. However, like all silesitids, these have a simpler, less incised suture with projected, not



retracted umbilical elements, and lack ventral tubercles. The Barremian *Silesites* itself has oval whorls and ribs which cross the venter. Moreover, in all Silesitidae the ribs branch, if at all, high up the sides, not from the umbilical tubercle.

*Feruglioceras* Leanza, 1967, type species *F. piatnitzkyi* Leanza, from the *Sanmartinoceras patagonicum* Zone (probably Upper Aptian (see Leanza 1970: 258; Thomson 1974: 43)) of the Lago San Martin Formation of Patagonia, seem to be the closest described genus to *Umsinenoceras*. (Note: In 1967 Leanza (1967: 156) established *Feruglioceras* with *F. piatnitzkyi* sp. nov. as type and sole species. He differentiated his three specimens from *Pseudohaploceras* at the generic level and (1967: 157) at the specific level from '*Silesites*' *desmoceroides* Stolley (1912: 7) with which Bonarelli (1921: 22) and, following him, Feruglio (1936) and Piatnitzky (1938) had misidentified them. In the authors' view this satisfies Article 13(a)(i) of the *I.C.Z.N. Rules* in respect of the names *piatnitzkyi* and *Feruglioceras*.) It is characterized by its compressed subtabulate whorl section, frequent flexuous constrictions separated by extremely sharp, fine, irregularly branching ribs, fifteen or more between constrictions. *Feruglioceras* is probably derived from *Pseudohaploceras* by increase in closeness, fineness and flexuousness of ribs. In comparison, *Umsinenoceras* has lower and somewhat weaker ribs, becoming feebler and more distant on the body chamber, and developing prominent ventrolateral tubercles, but it resembles *Feruglioceras* closely in its subtabulate venter, degree of evolution, sinuous ribs branching in bundles from fine umbilical tubercles, and the frequent constrictions parallel to the ribs.

There are considerable similarities between *Umsinenoceras* and various members of the Kossmaticeratidae. This family is currently divided into subfamily Marshallitinae Matsumoto, 1955, ranging probably from the Upper Aptian (?*Hulenites* from Japan (see Obata 1967: 67; Matsumoto, Kanmera & Sakamoto 1968: 145)) to Cenomanian and perhaps Turonian (Matsumoto 1955, 1956), and subfamily Kossmaticeratinae, ranging from Upper Turonian to Maastrichtian. Marshallitinae apparently evolved from a compressed puzosiine form by increased compression, a tendency to flatten and lose ribs on the venter, and increasingly prorsiradiate constrictions. In the earliest form, *Hulenites* Matsumoto, 1955, the constrictions do not yet truncate the ribs behind them, as is characteristic of most Kossmaticeratidae.

*Hulenites* (Upper Aptian to Upper Albian) is more compressed and involute than *Umsinenoceras*, with a much smaller umbilicus. The ribbing is fairly similar as are the constrictions, but *Hulenites* does not have the smooth tabulate venter of the adult shell nor the ventrolateral tuberculation of *Umsinenoceras*. *Marshallites* Matsumoto, 1955, which ranges from Cenomanian to Lower Turonian, is still more high-whorled, compressed and involute, and the constrictions clearly truncate the ribs. It resembles *Umsinenoceras* in the fine umbilical tubercles, but the ribs are not weakened on the venter. *Holcodiscoides* Spath, 1922, from the Turonian of southern India, resembles *Umsinenoceras* in being evolute with flat sides and having ventrolateral tubercles, but it is much further removed

from the ancestral puzosiiforme type. It has almost square whorls with recti-radiate to slightly prorsiradiate, nearly straight ribs, and prorsiradiate constrictions, all crossing the venter nearly transversely.

Other members of the Marshallitinae, *Eomadrassites* Matsumoto, 1955, with irregular strong umbilical, ventrolateral and siphonal tubercles, *Eogunnarites* Wright & Matsumoto, 1954, with depressed whorl section and olcostephanoid ribbing, and *Mikasaïtes* Matsumoto, 1956, with fine ribbing crossing the venter transversely and distinct siphonal tubercles, are all readily distinguished from *Umsinenoceras*.

In view of the resemblance between *Feruglioceras* and *Umsinenoceras* on the one hand, and *Hulenites* and *Marshallites* on the other, the question arises whether the former two genera should be placed in the Marshallitinae. The general shell form, ribbing and relatively simple suture with moderately retracted suspensive lobe would all fit in the Kossmaticeratinae, but there are distinct contrary indications. *Umsinenoceras* does not have the most characteristic feature of the Kossmaticeratinae, i.e. constrictions that truncate the ribs. Moreover, Marshallitinae do not have such strongly projected ventral ribbing as do *Feruglioceras* and *Umsinenoceras*. The sutures do not help in deciding. Those of *Marshallites* itself are much more incised and complex and, indeed, more puzosiiforme than those of *Umsinenoceras*, although later Kossmaticeratinae may have simpler sutures, like those of the new genus.

On balance, it appears to us that *Umsinenoceras* is closely related to *Feruglioceras*, and an offshoot of *Pseudohaploceras* or an allied Southern hemisphere genus that was independent of, though in some ways similar to, the Northern hemisphere *Hulenites* and *Marshallites* line. If this is so it would be misleading to place *Feruglioceras* and *Umsinenoceras* in the Marshallitinae, and it is in the authors' view better to retain them for the time being in the Puzosiinae.

#### ACKNOWLEDGEMENTS

We are grateful to Dr I. Hayami, Tokyo, Dr M. K. Howarth and Mr D. Phillips of the British Museum (Natural History), and the staff of the Geological Collections, University Museum, Oxford, and the South African Museum, Cape Town, for their help in many ways, and to Professor T. Matsumoto, Kyushu University, who commented on an earlier draft of the paper. The financial assistance of the Trustees of the Sir Henry Strakosch Bequest, the National Environmental Research Council, and Wolfson College, Oxford, are gratefully acknowledged.

#### REFERENCES

- BONARELLI, G. 1921. In: Bonarelli, G. & Nagéra, J. J. Observaciones geológicas en las inmediaciones del Lago San Martín (Territorio de Santa Cruz). *Boln Dir. gen. Minas Geol. Hidrol., B. Aires* (B) 27: 1-39.
- FERUGLIO, E. 1936. *Palaeontographica Patagonica*. Pt. 1. *Memorie Inst. geol. miner. Univ. Padova* 11: 1-381.

- KENNEDY, W. J. & KLINGER, H. C. 1975. Cretaceous faunas from Zululand and Natal, South Africa. Introduction, Stratigraphy. *Bull. Br. Mus. nat. Hist. (Geol.)* **25**: 263-315.
- LEANZA, A. F. 1967. Anotaciones sobre los fósiles jurasico-cretacicos de Patagonia austral (coleccion Feruglio) conservados en la Universidad de Bologna. *Act. geol. lilloana* **11**: 121-188.
- LEANZA, A. F. 1970. Ammonites nuevos o poco conocidos de Aptiano, Albiano y Cenomanino de los Andes australes con notas acerca de su posición estratigráfica. *Revta. Asoc. geol. argent.* **25**: 197-261.
- MATSUMOTO, T. 1955. Family Kossmaticeratidae from Hokkaido and Saghalien. *Jap. J. Geol. Geogr.* **26**: 115-165.
- MATSUMOTO, T. 1956. Further notes on the Kossmaticeratids from Hokkaido. *Jap. J. Geogr.* **27**: 173-187.
- MATSUMOTO, T., KANMERA, K. & SAKAMOTO, H. 1968. Notes on two Cretaceous Ammonites from the Tomochi Formation of Kyushu. *Jap. J. Geol. Geogr.* **39**: 139-148.
- OBATA, I. 1967. Lower Cretaceous Ammonites from the Miyako Group. *Trans. Proc. palaeont. Soc. Japan* (n.s.) **66**: 63-72.
- PIATNITZKY, A. 1938. Observaciones geológicas en el Oeste de Santa Cruz (Patagonia). *Boln. Ints. petrol.* **165**: 45-85.
- THOMSON, M. R. A. 1974. Ammonite faunas of the Lower Cretaceous of south-eastern Alexander Island. *Br. Antarct. Surv. Sci. Rep.* **80**: 1-44.
- SPATH, L. F. 1922. On the Senonian ammonite fauna of Pondoland. *Trans. R. Soc. S. Afr.* **10**: 113-147.
- STOLLEY, E. 1912. Ueber einige Cephalopoden aus der Unteren Kreide Patagoniens. *Arkiv. Zool.* **7**: 13-18.
- ZITTEL, K. A. VON. 1895. *Grundzüge der Palaeontologie*. Munich & Leipzig.
- WRIGHT, C. W. & MATSUMOTO, T. 1954. Some doubtful ammonite genera from Japan and Saghalien. *Mem. Fac. Sci. Kyushu Univ. (D)* **5**: 107-134.



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Names of new taxa, combinations, synonyms, etc., when used for the first time, must be followed by the appropriate Latin (not English) abbreviation, e.g. gen. nov., sp. nov., comb. nov., syn. nov., etc.

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Synonymy arrangement should be according to chronology of names, i.e. all published scientific names by which the species previously has been designated are listed in chronological order, with all references to that name following in chronological order, e.g.:

#### Family Nuculanidae

*Nuculana (Lembulus) bicuspidata* (Gould, 1845)

Figs 14–15A

*Nucula (Leda) bicuspidata* Gould, 1845: 37.

*Leda plicifera* A. Adams, 1856: 50.

*Laeda bicuspidata* Hanley, 1859: 118, pl. 228 (fig. 73). Sowerby, 1871: pl. 2 (fig. 8a–b).

*Nucula largillierii* Philippi, 1861: 87.

*Leda bicuspidata*: Nicklès, 1950: 163, fig. 301; 1955: 110. Barnard, 1964: 234, figs 8–9.

Note punctuation in the above example:

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Note standard form of writing South African Museum registration numbers and date.

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WILLIAM JAMES KENNEDY  
CLAUDE WILLIAM WRIGHT

&

HERBERT CHRISTIAN KLINGER

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(b) Full references at the end of the paper, arranged alphabetically by names, chronologically within each name, with suffixes *a*, *b*, etc. to the year for more than one paper by the same author in that year, e.g. Smith (1969a, 1969b) and not Smith (1969, 1969a).

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 KOHN, A. J. 1960b. Spawning behaviour, egg masses and larval development in *Conus* from the Indian Ocean. *Bull. Bingham oceanogr. Coll.* 17 (4): 1-51.  
 THIELE, J. 1910. Mollusca: B. Polyplacophora, Gastropoda marina, Bivalvia. In: SCHULTZE, L. *Zoologische und anthropologische Ergebnisse einer Forschungsreise im westlichen und zentralen Süd-Afrika* 4: 269-270. Jena: Fischer. *Denkschr. med.-naturw. Ges. Jena* 16: 269-270.

(continued inside back cover)

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DISCOVERY OF THE ORIENTAL LATRINE FLY  
*CHRYSOMYIA MEGACEPHALA* (FABRICIUS)  
ALONG THE SOUTH-WESTERN COAST OF  
SOUTH AFRICA

By

A. J. PRINS

Cape Town      Kaapstad



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# DISCOVERY OF THE ORIENTAL LATRINE FLY *CHRYSOMYIA MEGACEPHALA* (FABRICIUS) ALONG THE SOUTH-WESTERN COAST OF SOUTH AFRICA

By

A. J. PRINS

*South African Museum, Cape Town*

(With 5 figures)

[MS. accepted 4 January 1979]

## ABSTRACT

While investigating the biology and life histories of certain Diptera infesting decaying seaweed and organic matter along the shore, *Chrysomya megacephala* was discovered during March 1978 in association with *Lucilia sericata* in a dead sea-gull at Ysterfontein.

It could have reached the coast either as a mature fly or as an immature stage by drifting ashore from passing ships.

Adult and immature stages are described and compared with those of the related *Chrysomya chloropyga*. Third stage larvae of these two species differ only slightly, but differences between the male genitalia are fairly conclusive. Both immature and adult stages are quite different from those of *L. sericata*.

It was not possible to determine the length of the larval life, but pupal stages lasted 4 days at room temperature.

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## INTRODUCTION

While investigating the biology and life histories of certain Diptera frequenting and infesting decomposing seaweed and organic matter along the coast and shores of the southern and western Cape, the author made an important discovery, namely the occurrence of the oriental latrine fly *Chrysomya megacephala* (Fabricius) in South Africa.

As this species of *Chrysomya* has never before been found in South Africa, it is important that certain observations made on the material at the author's disposal, its life history, imago, larval and pupal stages, should be recorded to enable its future identification and separation from the related and known South African species of *Chrysomya* and those of the genus *Lucilia*.

The oriental latrine fly, also known as the Indian Bazaar bluebottle, is widely distributed in the Far East, including Australasia. Although it occurs in the Malagasy Region, it was unknown in Africa until its recent discovery in Ghana and Senegal during 1977 (Kurahashi 1978). However, dead sea-gulls collected at Ysterfontein beach during March 1978 produced about six maggots

of this species from which three adult flies were reared. These maggots were in association with those of the green blowfly (common green-bottle) *Lucilia sericata* (Meigen) which formed the main constituent of this population. Several further attempts to collect more specimens along this coast from Milnerton to Saldanha were in vain. Despite the isolation of this discovery, it was considered important enough to give a brief description of the stages that were found for comparison with the related *C. chloropyga* (Wiedemann) and with *L. sericata* and to attempt a possible explanation of the fly's appearance at Ysterfontein.

### METHOD

Maggots that had been collected from dead sea-birds found on the beaches along the west coast from Milnerton to Elands Bay were sorted into different groups according to the size and shape of the posterior spiracles. They were then placed into glass jars containing a pupation medium of clean, damp beach sand. Their natural food was supplied as far as possible and the jars were covered with gauze cloth to prevent the adults from escaping. Slides were made of the genitalia and the drawings were made by means of a camera lucida.

### DISCUSSION


Ships from the Far East *en route* to Europe pass the west coast of South Africa in the vicinity of Dassen Island at an average distance of about 10 to 13 km from the shore. Ordinary house-flies have been found to travel about 33 km (Oldroyd 1964), and Hindle (1914: 311) even states, 'After a careful examination of all our results we can state definitely that flies tend to travel either directly against or across the wind'. He states further (Hindle 1914: 321), 'Flies may travel against the wind, being attracted by any odours it may convey from a source of food'. It is, therefore, possible that blowflies on a passing ship could have reached the shore and survived long enough to find a suitable breeding medium.

*C. megacephala* is a necrophagous species (Patton 1922) with an apparently long life-span. According to Wijesundara (1957*b*) the mean duration was 57 days at a room temperature of 24 to 29°C and a relative humidity ranging from 72 to 100 per cent, a condition which is similar to that along our west coast. The average percentage humidity, recorded by the Department of Transport in the Langebaan Road area during November to March for the period 1975 to 1977, varied from 60 to 70 per cent. This ability, together with a fairly short larval life of a little more than 3 to about 5 days (Wijesundara 1957*a*) probably contributed to its presence at Ysterfontein. Surface drift could also account for its presence, as species of the warm-water plankton of the Indian Ocean have often been found on the beaches north-west of Cape Town. It is also a well-known fact that the seeds of the legume *Mucuna gigantea quadrialata* from East Africa are sometimes washed up on the beach at Lambert's Bay (Muir 1932, 1934). Water of the warm Agulhas current mixed with cold Atlantic

water is often pushed round the Cape of Good Hope (Isaac 1937), the penetration being at maximum during the summer and autumn and is 'aided by the South East Trade winds' (Shannon 1966) and may even reach as far north as 32°S (Shannon 1966; Schell 1968). The presence of this surface water around Dassen Island will inevitably result in the drifting ashore near Ysterfontein of infested refuse or debris thrown overboard from a ship passing this area during the late summer, especially trawlers which often sail very close to the shore.

## DESCRIPTION OF THE STAGES

### IMAGO (Fig. 1A-C)

Metallic greenish with narrow blackish crossbands on the posterior borders of the abdominal segments, rather similar to *C. chloropyga* both in size and appearance, but lacking the  marks on the presutural area of the mesonotum. Genal area and genal hairs of the flies collected were of a definite golden yellow. Antennal segments reddish, the arista brown. Anterior thoracic spiracle blackish-brown. (In all the other South African species of *Chrysomya* found in decaying birds along the coast, the spiracles are white or light coloured.) The silky hairs on the sternopleuron are dark to almost blackish, especially in the male; in both *C. chloropyga* and *C. albiceps* the hairs are pale to almost white.

The males are easily separated from the females, and from those of other South African species belonging to this genus, by the sharply demarcated large upper and smaller lower facets of the compound eyes (Fig. 1C). They are also easily separated from the males of the other species by the rounded anterior borders of the head when seen from above (Fig. 1B), the parafrontalia not protruding (it is protruding in the other South African species).

As in *C. chloropyga* only two vertical bristles are present in the males (Fig. 1B-D), but they are much shorter in *C. megacephala*. In both the above species the prostigmatic bristles are present, but absent in *C. albiceps* which, in addition, has four verticals, both in the males and females. *L. sericata*, which also has prostigmatic bristles and two verticals in the case of the males, may easily be separated from *Chrysomya* species by the more strongly developed acrosticals on the presutural area of the mesonotum, especially in the males. Genitalia also differ.

In the male genitalia of *C. megacephala* the cerci and paralobi of the epandrium (Fig. 2E) differ from those of *C. chloropyga* (Fig. 2B), especially the paralobi which have much broader bases. This is easily seen in the mounted specimens. The phallosome has broad membranal lobi in both *C. megacephala* (Fig. 2F-G) and *C. chloropyga* (Fig. 2C-D), the theca (not visible in the drawings) is small in both, the phallus elongated and sclerotized, the harpes much longer in *C. megacephala* than in *C. chloropyga* and also closer together, and the vesicae (as in *C. chloropyga*) situated further towards the apex between the lobi. In *L. sericata* the harpes (Fig. 2H) are long and display almost the same



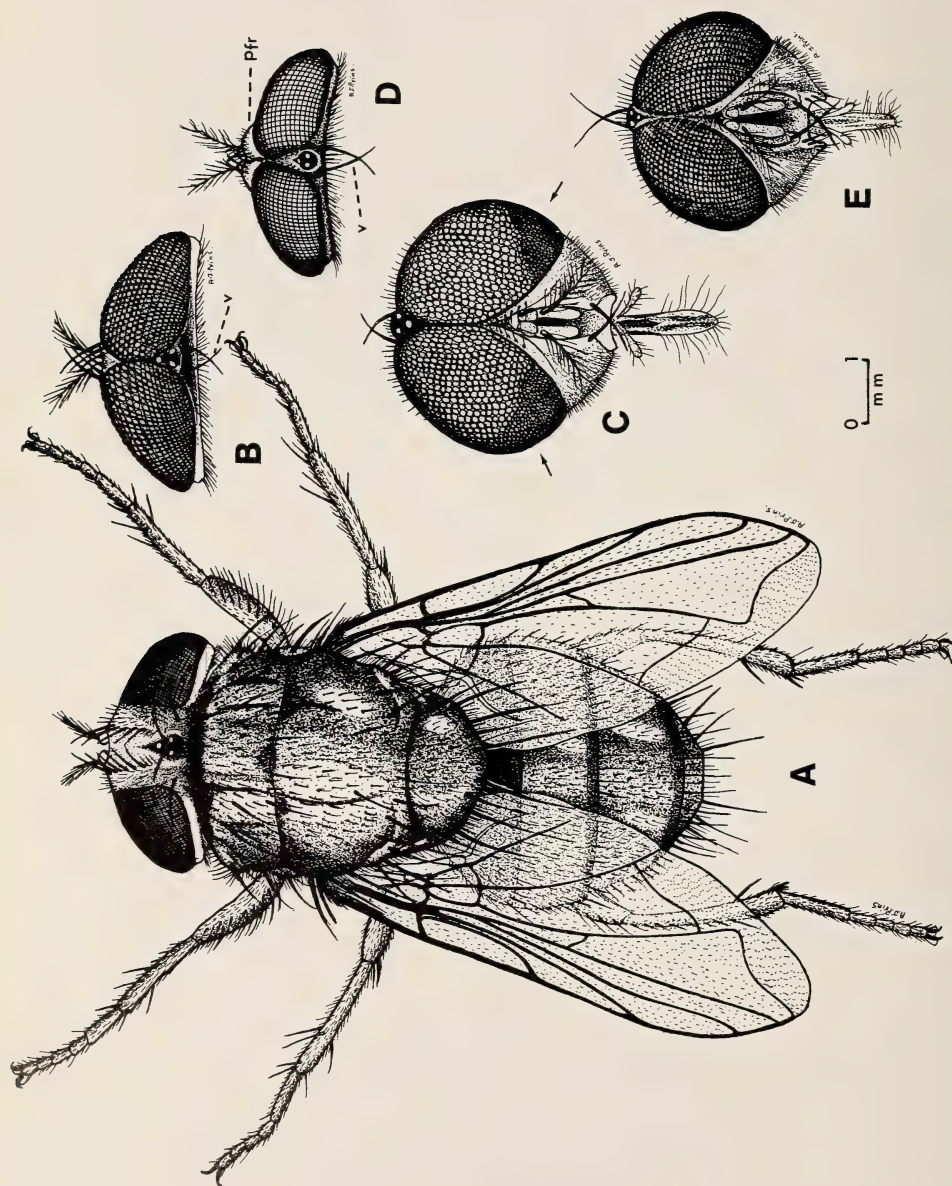


Fig. 1. A-C. *Chrysomya megacephala*.

A. ♀. B. Head of ♂ from above. C. Head of ♂ from above. D-E. *Chrysomya chloropyga*. D. Head of ♂ from above. E. Head of ♂ from the front. Pfr — parafrontalia, v — verticals.

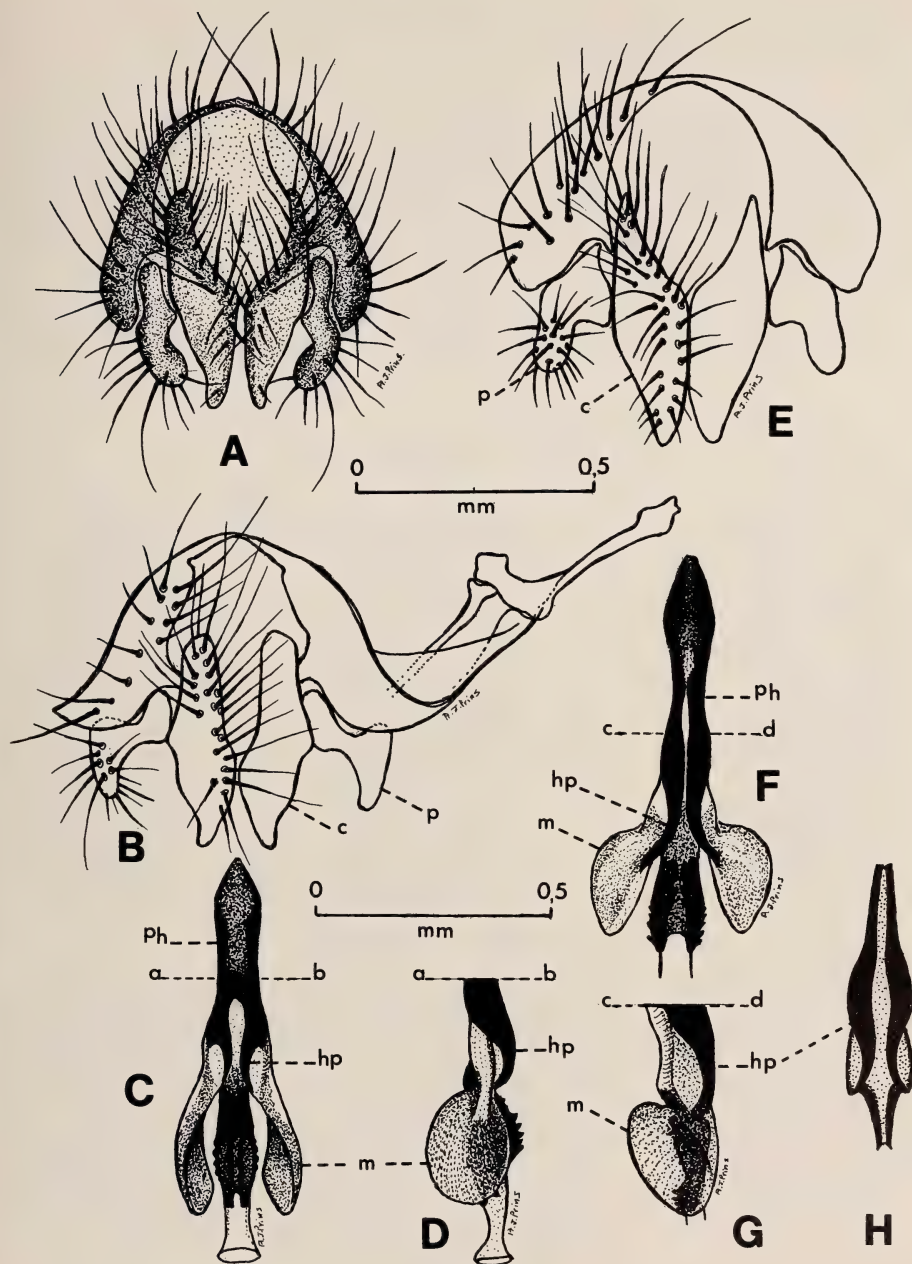


Fig. 2. Male genitalia.

A-D. *Chrysomya chloropyga*. A. Cerci and paralobi (living specimen). B. Cerci and paralobi (slide). C. Phallosome (slide). D. Apical part of Phallosome from side.

E-G. *Chrysomya megacephala*. E. Cerci and paralobi (slide by Dr Zumpt). F. Phallosome (slide). G. Apical part of Phallosome from side. c—cercus, hp—harpes, m—membranal lobus, p—paralobus, Ph—phallus.

H. *Lucilia sericata*. Apical part of Phallosome from the front.

pattern as in *C. megacephala*, although they are further apart when seen from above and the broad lobes are absent.

#### LARVA (Fig. 3A-F)

The various larval instars have been described by Patton (1922*a*, 1922*b*), Wijesundara (1957), and Zumpt (1965). During the recent surveys only third instar maggots which were almost inseparable from those of *C. chloropyga* were collected.

In specimens that were examined, the dorsal outline of the labial sclerites or mouth hooks of the cephalopharyngeal skeleton (Fig. 3C) when seen from the side is widely convex, meeting the superior basal face in a somewhat rounded

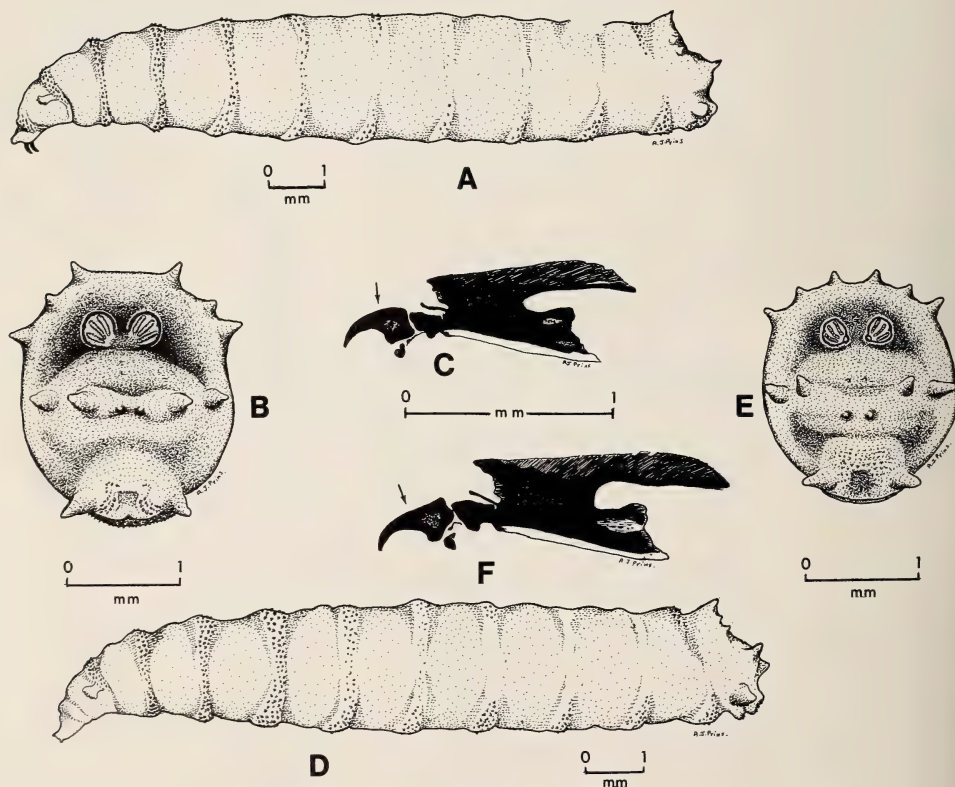


Fig. 3.

A-C. *Chrysomya megacephala*. A. Full-grown maggot from side. B. Posterior part of maggot showing the spiracles. C. Cephalo-pharyngeal skeleton.

D-E. *Lucilia sericata*. D. Full-grown maggot from side. E. Posterior part of maggot showing the spiracles.

F. *Chrysomya chloropyga*. Cephalo-pharyngeal skeleton.



angle. In *C. chloropyga* the dorsal surface is more straight and posteriorly even slightly concave and meets the superior basal face in a somewhat raised and more acute angle (Fig. 3F); this appeared to be the only difference between the two species. Zumpt (1965: 90) maintains that the distance between the posterior peritremes may serve to distinguish the larvae of *C. megacephala* from *C. chloropyga*; however, the few maggots of *C. megacephala* examined differ considerably in this character. In the sample made the peritremes are separated by one-third to four-sevenths of this diameter in *C. megacephala* and by three-eighths to five-ninths the diameter in *C. chloropyga*. Separation of the two species by means of this characteristic therefore seemed impossible. They are, however, easily distinguished from the larvae of *L. sericata* which has closed peritremes (Fig. 3E).

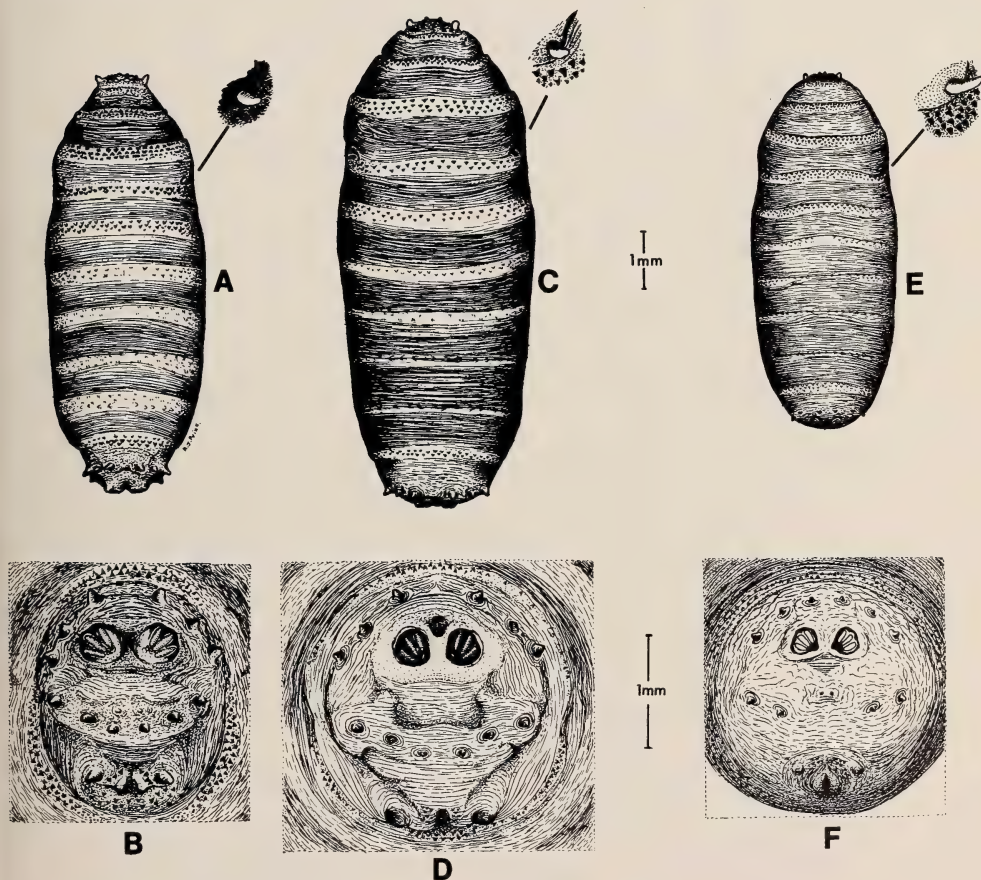


Fig. 4. A, C, E. Puparia from above. B, D, F. Posterior parts of puparia showing the projections and spiracles.

A-B. *Chrysomyia chloropyga*. C-D. *C. megacephala*. E-F. *Lucilia sericata*.



## PUPARIUM (Figs 4A-F, 5A-C)

Brown to mahogany brown and finely and transversely striate with very short, brown respiratory horns (Fig. 4C). The posterior projections round the stigmal plates small to almost obsolete, the ridge bearing the projections not so well marked as in specimens of *C. chloropyga* that were examined. Posterior spiracles only slightly protuberant. Pupae found vary from 8,6 to 9,3 mm in length. In *C. chloropyga* the pupae are usually brown after pupation but soon become dark-brown to almost black, otherwise they are similar to those of *C. megacephala* except that the anterior apex is more triangularly shaped (Fig. 4A) and the posterior spiracles much more protuberant. The posterior projections are usually better developed and the spinules on the anterior part of the body also much stronger in *C. chloropyga*. In *L. sericata* (Figs 4E-F, 5A) the transverse striations on the body are very fine and sometimes even obsolete and the posterior projections usually inconspicuous to very small. The posterior

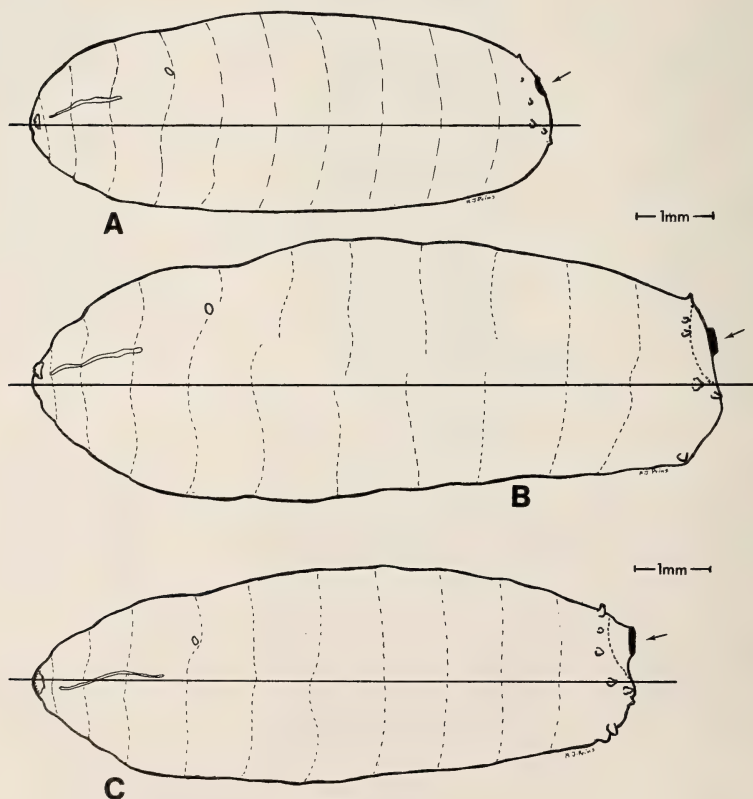


Fig. 5. Puparia from the side.

A. *Lucilia sericata*. B. *Chrysomya megacephala*. C. *C. chloropyga*.

end of the puparia is rounded in this case and the posterior spiracles are flush with the surface.

#### BIOLOGY

The life history of this fly is described by Wijesundara (1957*a*, 1957*b*) who gives the mean duration of the whole cycle in Ceylon from egg to adult as 8 days and 12 hours of which 100 hours are occupied by the pupal stage. It was impossible to determine the larval life from the specimens collected as they were nearly mature, but the pupal stage lasted four days at a room temperature of 29°C, the flies emerging long before *Lucilia* in which case the pupal stage was 7 to 8 days.

According to Zumpt (1965) the larvae may become facultative parasites in man and animals.

#### ACKNOWLEDGEMENTS

I wish to express my gratitude to Dr A. J. Hesse, formerly of the South African Museum, for his advice and encouragement regarding the contents of this manuscript and to Dr F. Zumpt of the South African Institute for Medical Research for his comments and for identifying the flies.

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#### REFERENCES

- HINDLE, E. 1914. The flight of the house fly. *Proc. Camb. phil. Soc.* **17**: 310-313.
- ISAAC, W. E. 1937. South African coastal waters in relation to ocean currents. *Geogr. Rev.* **27**: 651-664.
- KURAHASHI, H. 1978. The oriental Fly: *Chrysomya megacephala* (Fab.) newly recorded from Ghana and Senegal, West Africa. *Kontyn, Tokyo* **46**: 432.
- MUIR, J. 1932. The beach drift of South Africa. *J. Bot. Soc. S. Afr.* **18**: 5-10.
- MUIR, J. 1934. The correlation of arrival sites of alien seeds with ocean currents. *S. Afr. geogr. J.* **17**: 13-18.
- OLDROYD, H. 1964. The natural history of flies. London: Wiedenfeld and Nicolson.
- PATTON, W. S. 1922*a*. Some notes on Indian Calliphorinae Part III. *Chrysomya megacephala* Fab. (Dux Esch), the common Indian bluebottle whose larvae occasionally cause cutaneous myiasis in animals and *Chrysomya nigriceps* sp. nov., the common bluebottle of the Nilgiris. *Indian J. med. Res.* **9**: 555-560.
- PATTON, W. S. 1922*b*. Some notes on Indian Calliphorinae Part VI. How to recognise the Indian Myiasis producing flies and their larvae, together with some notes on how to breed them and study their habits. *Indian J. med. Res.* **9**: 635-653.
- SCHELL, I. I. 1968. On the relation between winds off South West Africa and the Benguela Current and Agulhas Current penetration in the South Atlantic. *Dt. hydrogr. Z.* **21**: 109-117.
- SHANNON, L. V. 1966. Hydrology of the South and West coasts of South Africa. *Investl Rep. Div. Sea Fish. S. Afr.* **58**: 1-62.
- WIJESUNDARA, D. P. 1957*a*. The life history and bionomics of *Chrysomya megacephala* (Fab.). *Ceylon J. Sci. (B)* **25**: 169-185.
- WIJESUNDARA, D. P. 1957*b*. On the longevity of the adult of *Chrysomya megacephala* (Fab.) under controlled humidity. *Ceylon J. Sci. (B)* **25**: 187-192.
- ZUMPT, F. 1965. Myiasis in Man and animals in the old world. London: Butterworths.



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Names of new taxa, combinations, synonyms, etc., when used for the first time, must be followed by the appropriate Latin (not English) abbreviation, e.g. gen. nov., sp. nov., comb. nov., syn. nov., etc.

An author's name when cited must follow the name of the taxon without intervening punctuation and not be abbreviated; if the year is added, a comma must separate author's name and year. The author's name (and date, if cited) must be placed in parentheses if a species or subspecies is transferred from its original genus. The name of a subsequent user of a scientific name must be separated from the scientific name by a colon.

Synonymy arrangement should be according to chronology of names, i.e. all published scientific names by which the species previously has been designated are listed in chronological order, with all references to that name following in chronological order, e.g.:

Family Nuculanidae

*Nuculana* (*Lembulus*) *bicuspidata* (Gould, 1845)

Figs 14–15A

*Nucula* (*Leda*) *bicuspidata* Gould, 1845: 37.

*Leda plicifera* A. Adams, 1856: 50.

*Laeda bicuspidata* Hanley, 1859: 118, pl. 228 (fig. 73). Sowerby, 1871: pl. 2 (fig. 8a–b).

*Nucula largillierti* Philippi, 1861: 87.

*Leda bicuspidata*: Nicklès, 1950: 163, fig. 301; 1955: 110. Barnard, 1964: 234, figs 8–9.

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semicolon separates more than one reference by the same author

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*Holotype*

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Punctuation should be loose, omitting all not strictly necessary

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Specific name must not stand alone, but be preceded by the generic name or its abbreviation to initial capital letter, provided the same generic name is used consecutively.

Name of new genus or species is not to be included in the title: it should be included in the abstract, counter to Recommendation 23 of the Code, to meet the requirements of Biological Abstracts.



A. J. PRINS

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# ANNALS

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Major headings of the paper are centred capitals; first subheadings are shouldered small capitals; second subheadings are shouldered italics; third subheadings are indented, shouldered italics. Further subdivisions should be avoided, as also enumeration (never roman numerals) of headings and abbreviations.

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The number of the figure should be lightly marked in pencil on the back of each illustration.

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(b) Full references at the end of the paper, arranged alphabetically by names, chronologically within each name, with suffixes *a*, *b*, etc. to the year for more than one paper by the same author in that year, e.g. Smith (1969a, 1969b) and not Smith (1969, 1969a).

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- BULLOUGH, W. S. 1960. *Practical invertebrate anatomy*. 2nd ed. London: Macmillan.
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- FISCHER, P.-H., DUVAL, M. & RAFFY, A. 1933. Études sur les échanges respiratoires des littorines. *Archs Zool. exp. gén.* 74: 627-634.
- KOHN, A. J. 1960a. Ecological notes on *Conus* (Mollusca: Gastropoda) in the Trincomalee region of Ceylon. *Ann. Mag. nat. Hist.* (13) 2: 309-320.
- KOHN, A. J. 1960b. Spawning behaviour, egg masses and larval development in *Conus* from the Indian Ocean. *Bull. Bingham oceanogr. Coll.* 17 (4): 1-51.
- THIELE, J. 1910. Mollusca: B. Polyplacophora, Gastropoda marina, Bivalvia. In: SCHULTZE, L. *Zoologische und anthropologische Ergebnisse einer Forschungsreise im westlichen und zentralen Süd-Afrika* 4: 269-270. Jena: Fischer. *Denschr. med.-naturw. Ges. Jena* 16: 269-270.

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CRETACEOUS TRIGONIIDAE  
(MOLLUSCA, BIVALVIA) FROM THE  
BRENTON FORMATION, KNYSNA

By

MICHAEL R. COOPER

Cape Town      Kaapstad



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# CRETACEOUS TRIGONIIDAE (MOLLUSCA, BIVALVIA) FROM THE BRENTON FORMATION, KNYSNA

By

MICHAEL R. COOPER

*Department of Geology, University of Oxford\**

(With 12 figures)

[MS. accepted 22 February 1979]

## ABSTRACT

The trigoniid fauna from the Brenton Formation at Knysna is described, and two new species, *Steinmanella kensleyi* and *Pterotrigonia savagei*, are erected. The age of the fauna is discussed and considered to support a late Valanginian age for the Brenton Formation.

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## INTRODUCTION

Strata assigned to the Enon Formation of the Uitenhage Group crop out as a small outlier at Knysna, resting unconformably upon sandstones of the Ordovician Table Mountain Group (Fig. 1). Long regarded as Cretaceous, these sediments were recently assigned a Jurassic age (Dingle & Klinger 1972; Klinger *et al.* 1972). More recent information (Beer 1972; Stapleton & Beer 1976; McLachlan *et al.* 1976), however, would seem to confirm the early Cretaceous determination.

Fossils were first recorded from the Enon Formation of the Knysna-Plettenberg area in 1899 when Schwarz listed an *Ammonites* sp., *Trigonia* sp. and *Gervillia* sp., but without mentioning a locality. In 1906, Schwarz recorded a *Trigonia* sp. from Brentford Farm, Knysna, while Kitchin (1908), in his extremely important monograph of the Cretaceous invertebrate faunas of the Uitenhage basin, listed the following species collected by A. W. Rogers in 1905 from Brentford, Knysna: *Trigonia holubi?* sp. nov. (young individual), *Acanthodiscus* sp. and *Belemnites* sp. In 1909, Rogers recorded the following invertebrate fossils from Brentford or, as it is now known, Brenton-on-Lake: *Trigonia rogersi* Kitchin, *Nautilus* sp., *Ptychomya complicata* (Tate) 'or a shell like it', *Perna* sp., *Pentacrinus* sp. and *Cidaridites* spines. Schwarz (1915) was the

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Fig. 1. Locality map, with the outcrop of the Brenton Formation hatched and arrowed. 1—Table Mountain Sandstone, 2—Enon conglomerate. After Dingle & Klinger (1972).

first systematically to describe a fauna from these beds when he recorded the new species *Trigonia kitchini* (= *T. rogersi* Rogers non Kitchin), *Perna brentonensis* and *P. theseni*.

In his description of some ammonites from the Sundays River Formation, Spath (1930) referred the ammonite recorded by Kitchin (1908) to *Distoloceras* sp. and the belemnite to *Hibolites* sp.

Dingle & Klinger (1972) gave the first detailed description of the Brenton Formation, including measured sections and a review of the older literature, as well as describing an ostracod assemblage to which Dingle assigned a low Upper Jurassic age (with strong Callovian affinities). Klinger *et al.* (1972) redescribed the ammonite recorded by Kitchin (1908) and Spath (1920), assigning it to *Hybonoticeras* aff. *hildebrandti* (Beyrich).

More recently, however, detailed studies of the foraminifera (Beer 1972; Rigassi & Dixon 1972; Stapleton & Beer 1976; McLachlan *et al.* 1976), ostracods (Stapleton & Beer 1976; McLachlan *et al.* 1976), nannofossils (Stapleton & Beer 1976) and palynomorphs (Stapleton & Beer 1976) have all been taken to indicate a Cretaceous, and more specifically, a Neocomian age.

Although not yet recorded from the Brenton Formation, *Megatrighonia* (*Megatrighonia*) cf. *conocardiiformis* (Krauss) occurs in sandstones interbedded in Enon conglomerates at Robberg (Du Toit 1954; Cooper 1974). The latter deposit, recently formally termed the Robberg Formation (Rigassi & Dixon 1972), is related by Cooper (1974) to the same marine transgression that deposited the Brenton Formation.

## GEOLOGY

McLachlan *et al.* (1976) gave the following stratigraphic succession through the Brenton Formation, from above downwards:

- (iv) Unit I —1–2 m of grey, unfossiliferous silty shale.
- (iii) Unit II —0.15–1 m of hard, coarse-grained, conglomeratic sandstone rich in shell debris.
- (ii) Unit III—About 15 m of unfossiliferous grey mudstone with sandy to gritty and sometimes pebbly layers.
- (i) Unit IV—A highly fossiliferous, soft grey shale yielding fossiliferous calcareous nodules. This unit is at least 6 m thick.

According to McLachlan *et al.* (1976), units III and IV have yielded all the megafossils recorded by previous authors. However, the present collecting has shown *Iotrigonia* cf. *vau* (Sharpe), *Isognomon* sp., *Pterotrigonia savagei* sp. nov. and probably *P. kitchini*, together with cidaroid spines, oysters, reptilian and fossil wood to be present in unit II. Unit IV has yielded abundant *Steinmanella kensleyi* sp. nov., *I. theseni*, *I. brentonensis* and a 'Nautilus' sp., together with numerous small, undetermined bivalves. The ammonite described by Klinger *et al.* (1972) is preserved in a nodule and almost certainly comes from this unit.

The prefix SAM refers to specimens housed in the collections of the South African Museum, Cape Town, AM to specimens in the Albany Museum, Grahamstown, and RO to specimens in the collections of R. Oosthuizen of Zwartskraal, Prince Albert.

## SYSTEMATICS

Family **Trigoniidae** Lamarck, 1819

Subfamily Megatrigoniinae van Hoepen, 1929

Genus *Iotrigonia* van Hoepen, 1929

Type species *Iotrigonia crassitesta* van Hoepen, 1929

*Iotrigonia* cf. *vau* (Sharpe)

Figs 2–3

Compare

*Trigonia vau* Sharpe, 1856: 194, pl. 22 (fig. 5). Kitchin, 1908: 110, pl. 6 (figs 1–3).

*Material*

A single abraded specimen in the South African Museum with recrystallized test preserved, from unit II.

*Description*

The specimen is a poorly preserved right valve, but shows the chevrons on the flanks so typical of this genus. The anterior limb of the chevron is very narrow and directed obliquely across the flanks, while the posterior limb is



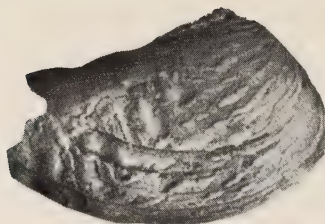


Fig. 2. *Iotrigonia* cf. *vau* (Sharpe).  
Right valve.  $\times 1$ .

broad and thick and directed strongly upwards (dorsally). The umbo is slightly recurved and situated about one-quarter of the shell length posteriorly. The marginal and inner carinae are not developed at the growth stages observed, while the area is ornamented by very faint growth striae.

#### Discussion

The Brenton example is closest to *I. vau* (Sharpe) (Fig. 3), and may well be conspecific; only the poor preservation of the Brenton specimen prevents the author from uniting them. '*Trigonia*' *dubia* Kitchin (Kitchin 1903) from the Oomia Beds of Kutch, southern India, closely resembles the present form, but differs in having the anterior limbs of the chevrons parallel to the concentric growth lines and not oblique as in *I. vau*.

*Iotrigonia stowi* (Kitchin) (Fig. 4) from the Sundays River Formation differs from *I. vau* in being more produced both posteriorly and anteriorly, and with a different sculpture pattern on the anterior portion of the flanks.

Other South African species of *Iotrigonia* are *I. crassitesta* van Hoepen (1929: 7, pl. 2 (figs 4–5), pl. 3 (figs 1–2)) (of which *I. inconstans* van Hoepen is a probable synonym) and *I. haughtoni* Rennie (1936: 340, pl. 41 (figs 1–4)), but none is liable to be confused with the present species.

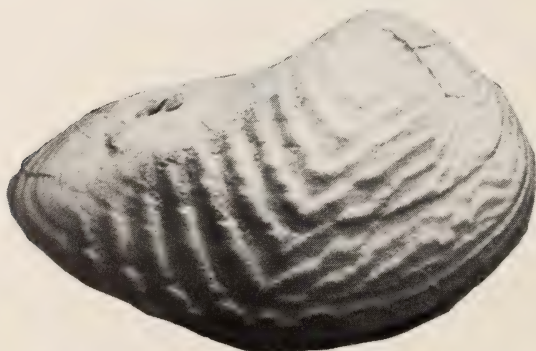


Fig. 3. *Iotrigonia vau* (Sharpe). Right valve of SAM-3976.  
 $\times 1$ . This is the original of the specimen figured by Kitchin  
(1908).



Fig. 4. *Iotrigonia stowi* (Kitchin).  
The holotype, after Kitchin (1908).  $\times 1$ .

Subfamily Pterotrigoniinae van Hoepen, 1929

Genus *Pterotrigonia* van Hoepen, 1929

Type species *Pterotrigonia cristata* van Hoepen, 1929

#### Discussion

Nakano (1974) considers the subfamily Pterotrigoniinae to include the following taxa: *Pterotrigonia* (*Pterotrigonia*), *P. (Rinetrigonia)*, *Scabrotrigonia*, *Acanthotrigonia* (*Acanthotrigonia*) and *A. (Metacanthotrigonia)*. However, within contemporaneous species populations there are intermediates between *Pterotrigonia* and *Rinetrigonia* and between *Acanthotrigonia* and *Scabrotrigonia*. Moreover, it is frequently difficult to place a species within any one of these genera/subgenera, and subsequently the author prefers to follow Cox (1969) in recognizing only *P. (Pterotrigonia)* and *P. (Scabrotrigonia)*, to which may now possibly be added *P. (Metacanthotrigonia)*.

*Pterotrigonia (Pterotrigonia) etheridgei kitchini* (Schwarz)

Fig. 5

*Trigonia rogersi* Rogers (*non* Kitchin), 1909: 130.

*Trigonia kitchini* Schwarz, 1915: 120, pl. 4 (figs 2-4). Pringle, 1960: 89.

*non Trigonia kitchini* Stoyanow, 1949: 82, pl. 14 (figs 4-10).

#### Material

The holotype, AM 3884, and a topotype example, SAM-D3067, are the only known specimens. Both retain recrystallized test and their preservation suggests that they may be from unit II at Brenton.

#### Description

The holotype shell is strongly inflated anteriorly and rostrate posteriorly. The umbones are strongly incurved and situated very close to the anterior face of the shell.



Fig. 5. *Pterotrigonia* (*Pterotrigonia*) *etheridgei kitchini* (Schwarz). Dorsal, anterior and lateral views of the holotype, AM 3884.  $\times 1$ .

The flanks are ornamented by prominent ribs which, in the anterior set, are flexuous and curve forwards so as to terminate along the anterior and anteroventral commissure. The posterior set is straight, but there is no clear distinction between the two sets of ribs. Except for a few rather prominent tubercles at the ventral end of the two ribs terminating along the anteroventral margin, discrete tubercles are absent.

The area is bordered dorsally by a distinct inner carina and ventrally by a prominent marginal carina in the early stages, but both these features weaken with maturity. The area is ornamented only by concentric growth striae. The escutcheon is broad, concave, lanceolate, probably extending much of the length



of the dorsal margin of the shell, and is ornamented by irregular, closely spaced, transverse costellae which are finely serrated and more or less normal to the dorsal commissure.

### Discussion

'*Trigonia*' *kitchini* closely resembles '*Trigonia*' *etheridgei* Lycett (1875: 127, pl. 27 (figs 1–3)) from the lowermost beds of the Atherfield Clay on the Isle of Wight, and thus of earliest Aptian age. It differs from Lycett's species only in having more transverse costellae on the escutcheon, and in having a few ventral tubercles on only two, not four, ribs. Schwarz's species is also of somewhat older age. However, the differences are so slight that the writer has no hesitation in regarding the two species as conspecific but, until the intra-specific variations in both populations are known, the slight differences are regarded as of subspecific value because of the somewhat different ages and the wide geographic separation of *P. etheridgei* and *P. kitchini*.

This species cannot be confused with any other South African form, but is most closely allied to *P. (P.) knighti* (Pringle) (1960: 90, pl. 1 (figs 1–3)) from the Sundays River Formation (late Valanginian). It differs in lacking coarse tuberculation along the whole length of the flank ribs.

*Pterotrigonia savagei* sp. nov. differs from *P. etheridgei kitchini* in being much less inflated anteriorly, more rostrate posteriorly, and with less strongly incurved umbones. There are also distinct, discrete tubercles along the ribs of the anterior set in *P. savagei*, while the transverse costellae ornamenting the escutcheon of *P. savagei* diverge anteriorly.

'*Trigonia*' *kitchini* Stoyanow (1949) is preoccupied by Schwarz's name and consequently requires a new name. The Arizonan species appears to be a *Buchotrigonia* closely allied to several other species from the same region and, until population studies are undertaken to determine the range of intraspecific variation amongst these forms, it seems unwise to propose a new specific name.

In view of the vast age difference, *P. (P.) evansana* (Meek) (Jones 1960: 436, pl. 59 (figs 6–7, 12, 15), pl. 60 (figs 1–11)) from the Coniacian to Lower Campanian of western North America bears a remarkable homoeomorphic resemblance to the present species (compare especially Jones 1960, pl. 60 (figs 6, 9)).

### *Pterotrigonia (Pterotrigonia) savagei* sp. nov.

Fig. 6

### Material

Four fragmentary specimens in the South African Museum, and eight examples in the collection of R. Oosthuizen. All retain recrystallized test.

### Holotype

RO 375 (SAM-PCK 5927) is designated as the holotype, the remaining examples are paratypes.



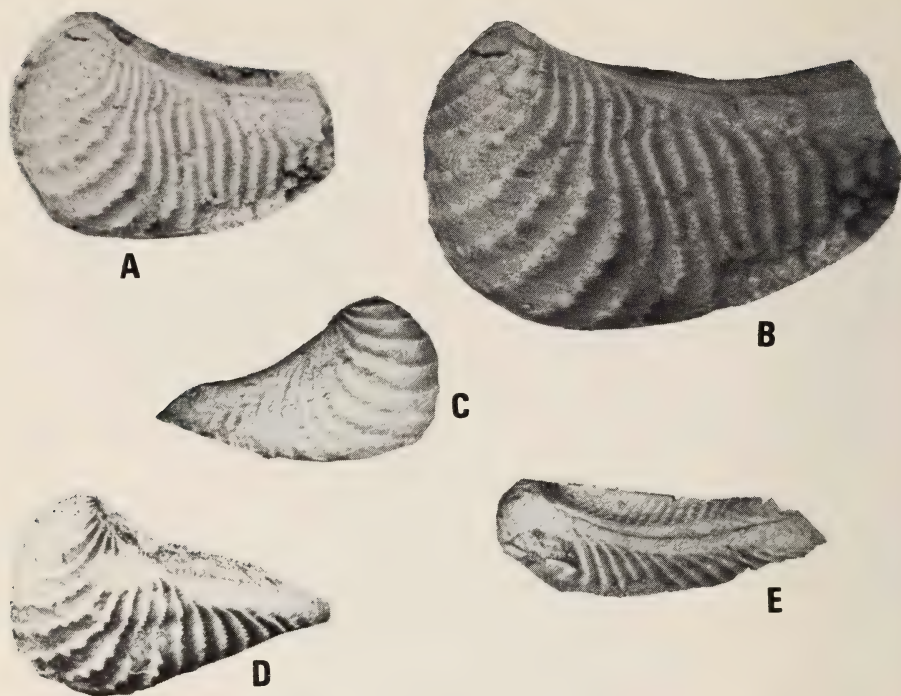


Fig. 6. *Pterotrigonia (Pterotrigonia) savagei* sp. nov. A. The holotype RO 375 (SAM-PCK 5927).  $\times 1$ . B. RO 375.  $\times 2$ . C-E. Paratypes in the collection of R. Oosthuizen. C. RO. 495-A (SAM-PCK 5929). D. RO 495-B (SAM-PCK 5930). E. RO 496 (SAM-PCK 5931).  $\times 1$ .

#### *Type locality*

Brenton-on-Lake, Knysna. Unit II.

#### *Etymology*

For Dr N. M. Savage of the University of Oregon, Eugene, whose enthusiasm and keen interest did much to further the author's palaeontological career.

#### *Diagnosis*

A species of *Pterotrigonia* characterized by the weak inflation of the valves, the prominent inner carina during the early growth stages, the numerous well-developed flank ribs in which the tuberculate anterior set curves strongly forwards so as to terminate along the anterior and anteroventral margins of the shell. The posterior set of flank ribs are almost straight and finely serrated. Area ornamented only with growth striae and a prominent median longitudinal furrow. Escutcheon with finely serrated, closely spaced costellae which diverge anteriorly.

### Description

The shell is weakly inflated anteriorly and strongly produced posteriorly. The umbones are moderately incurved and are situated a short distance posteriorly from the gently convex anterior margin. The nepionic stages are not clearly visible on any of the specimens, although there appear to have been concentric ribs on the flanks at this stage.

The flanks are ornamented with prominent ribs which are clearly divisible into an anterior and posterior set. The anterior set are crowded along the marginal carina (becoming more distantly spaced ventrally), from which they extend almost straight downwards before curving strongly forwards to terminate along the anterior and anteroventral margins. The ribs are initially finely serrated but immediately they start to curve forwards they thicken markedly and develop distinct tubercles. The posterior ribs are finely serrated throughout their length.

The area is ornamented only by transverse growth striae, while a deep, prominent median longitudinal furrow is present at the largest observed size (the holotype). The escutcheon is narrow, lanceolate, extending virtually the whole length of the dorsal margin of the shell. It is ornamented with closely spaced transverse ridges, serrated by the growth lines, which diverge anteriorly from the dorsal commissure.

### Discussion

The present species is closest to *P. (P.) rogersi* (Kitchin) (Fig. 7) from the Lower Cretaceous (late Valanginian) of the Uitenhage basin. It differs, however,

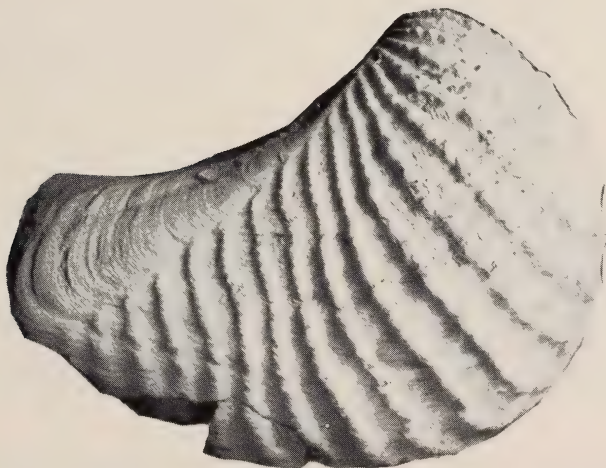


Fig. 7. *Pterotrigonia (Pterotrigonia) rogersi* (Kitchin).

Lateral view of the holotype (SAM-12954) in the South African Museum.  $\times 1$ .

in being less inflated than *P. rogersi*, with more clearly demarcated anterior and posterior sets of ribs, while the anterior set curves more strongly forwards than in the Uitenhage example, and is more densely ribbed at a comparable growth stage.

*Pterotrigonia jubata* van Hoepen (1929: 11, pl. 4 (figs 7–10)) bears a superficial resemblance to *P. savagei*, but differs in being more strongly inflated anteriorly, more rostrate posteriorly and much higher, while the costellae ornamenting the escutcheon diverge posteriorly in Van Hoepen's species. Moreover, *P. jubata* is of much younger age (late Albian) and probably does not bear separation from the European *P. aliformis* (Parkinson).

*Pterotrigonia savagei* also bears a superficial resemblance to *Megatrigonia conocardiiformis* (Krauss) (Kitchin 1908: 119, pl. 7 (figs 2–4)), from which it may be distinguished by its small size, finely tuberculate ribs, prominent inner carina and ornamented escutcheon.

Subfamily Myophorellinae Kobayashi, 1954

Genus *Steinmanella* Crickmay, 1930

Type species *Trigonia holubi* Kitchin, 1908

#### Discussion

Four subgenera are currently recognized within Crickmay's genus; these are *S. (Steinmanella)*, *S. (Yeharella)*, *S. (Setotrigonia)* and *S. (Litschkovitrigonia)*. Cox (1969) diagnosed *Steinmanella* s.s. as follows: 'Oblong to subtrigonal; area with strong irregular transverse ridges invading posteroventral part of the flank in some species; flank costae concentric near umbo, but oblique and tuberculate on most of the surface where they are either all continuous or become broken up and irregular anteriorly and ventrally.'

In *S. (Yeharella)* the carinae and transverse ridges are effaced across the area, while in *S. (Setotrigonia)* the flank costae extend on to the area, with a tendency for the carinae to become obsolete. In *S. (Litschkovitrigonia)* the nepionic growth stages are ornamented with V-shaped ribs which extend on to the area, while the later growth stages are more densely ribbed and with much weaker transverse ridges across the area. According to Cox (1969), *Steinmanella* is a wholly Cretaceous genus, and the Brenton species to be described below clearly belongs to this genus.

*Steinmanella (Steinmanella) kensleyi* sp. nov.

Fig. 8

*Trigonia holubi*? sp. nov. (young individual) Kitchin, 1908: 224.

#### Material

This species is abundant in the grey clays of unit IV of the Brenton Formation, but is extremely friable, so much so that of scores of fragmentary valves collected, only one complete specimen has been obtained. All the material retains recrystallized test.



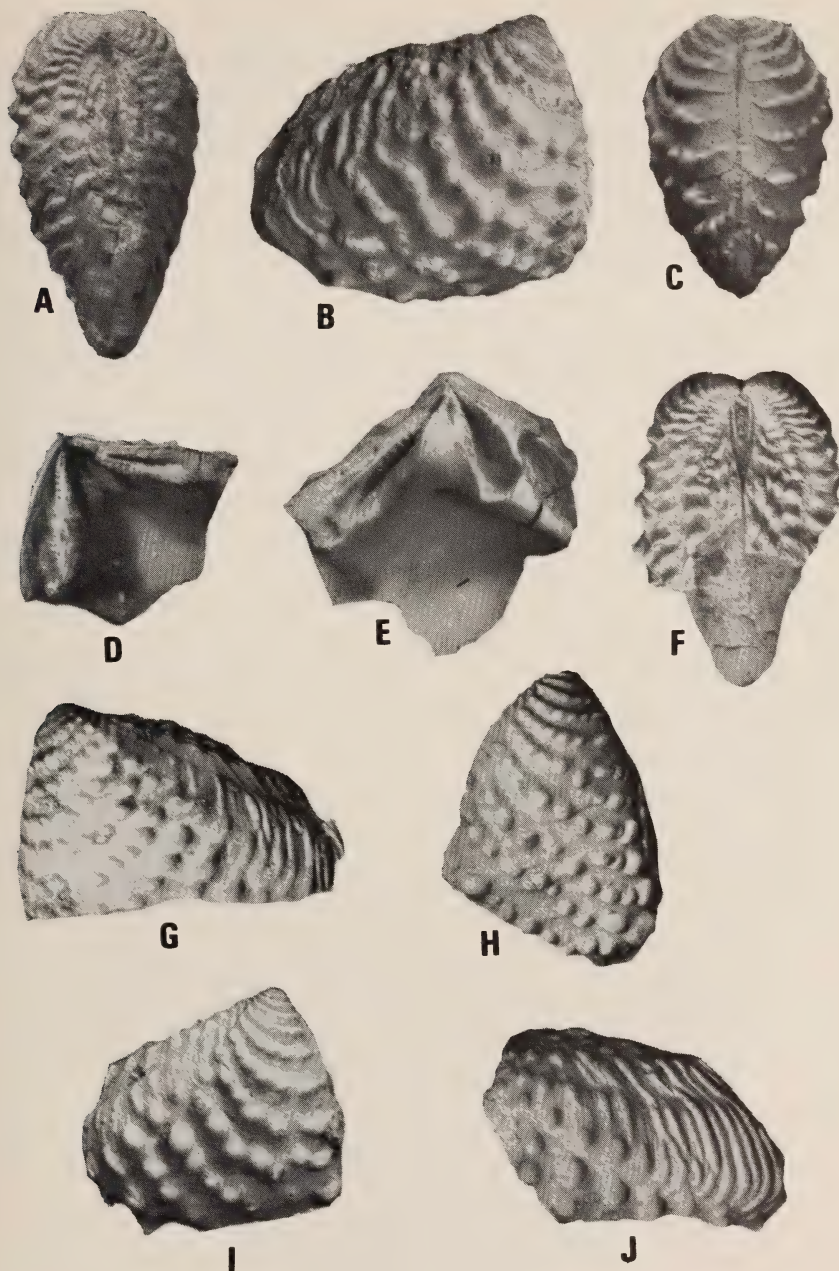


Fig. 8. *Steinmanella (Steinmanella) kensleyi* sp. nov. A–C. Dorsal, lateral and anterior views of the holotype RO 377 (SAM–PCK 5928). D. Cardinal area of right valve, RO 490. E. Cardinal area of left valve, RO 489. F. Dorsal view of a paratype, RO N24. G. Left valve of SAM–PCK 5922. H. Fragment of right valve, SAM–PCK 5293. I. Fragment of the area of a mature specimen, SAM–PCK 5924. J. Fragmentary right valve. All  $\times 1$ .



*Holotype*

The original of the specimen figured in Figure 8A–C, in the R. Oosthuizen Collection, RO 377 (SAM–PCK 5928), is designated as holotype. Paratype and abundant topotype material is housed in the South African Museum (SAM–PCK 5922–5924).

*Type locality*

Brenton-on-Lake, Knysna. Unit IV.

*Etymology*

For Dr B. F. Kensley of the Smithsonian Institution, Washington, who assisted in collecting much of the material.

*Diagnosis*

A moderately small species of *Steinmanella* in which the anterior margin is abruptly truncate, vertical, with terminal umbones, and the posterior broadly rounded. The thick flank costae are ornamented with coarse tubercles and curve forwards so as to terminate mostly along the anterior margin of the valve.

*Description*

Shell moderately small, longer than high, massive, subtrigonal in outline, with weakly inflated valves. The anterior margin is abrupt, perpendicular, with weakly incurved terminal umbones.

The nepionic stage of the area is ornamented by prominent costae which are continuous with those on the flank, but soon break up to form three rows of tubercles—the ventral row corresponds with the marginal carina, the central row lies just below (ventral) the median longitudinal furrow and delimits the dorsal margin of the area, while the dorsal row corresponds with the inner (escutcheon) carina. Posteriorly, the central and dorsal rows of tubercles elongate to form prominent, irregular, transverse ridges, between which are intercalated additional costae. At large sizes, the median longitudinal furrow is very indistinct and marked only by a slight fold in the ribs crossing the area.

The escutcheon is moderately narrow and long, about two-thirds of the dorsal shell length, and is ornamented with irregular rows of anteroposteriorly elongated tubercles of uneven height. These rows of tubercles diverge at a small angle from the dorsal commissure and posteriorly are seen to be continuous with the transverse ridges across the area. The ligament pit is lanceolate and extends for about one-third of the length of the escutcheon.

In the nepionic stages, the flank ornament comprises well-developed, concentric, nodular costae which weaken considerably on the flattish anterior face of the valves, and are entirely effaced prior to reaching the anterior commissure. With growth, the costae weaken while the tubercles strengthen so as to dominate the ornament. The flank costae tend to be slightly narrower than the interspaces separating them, and most of them curve forwards so as to

terminate along the anterior margin of the shell. The flanks are ornamented with very fine growth striae which cut obliquely across the ribbing.

The teeth are typically trigoniid. The central tooth of the left valve is very prominent and robust, while the anterior tooth is weakly developed, thin, lath-like, and is directed almost vertically downwards. The prominent anterior tooth of the right valve is directed vertically downwards, and is supported on a thickened ledge of shell. The posterior tooth is weakly developed, lath-like, and meets the anterior tooth at an angle of about  $60^{\circ}$ .

#### Discussion

This species most closely approaches *Steinmanella mamillata* (Kitchin) (Fig. 9) from the Oomia Group of Kutch, southern India. Kitchin's (1903) species differs from *S. kensleyi*, however, in having a more quadrate outline, while most of the flank ribs terminate along the ventral margin of the shell. This distinction is confirmed by topotype material in the British Museum (Natural History). The differences are not great, but, in view of the greater age of the Indian species (Uppermost Tithonian or Berriasian), they are considered sufficient for specific separation.

The Brenton species is a close homoeomorph of the Aptian '*Trigonia*' *bronni* Agassiz, as is indicated by a specimen in the collections of the South African Museum (D1622) (Fig. 10), from Perte-du-Rhône, France. The French species has, however, a more convex anterior margin, twice as many tubercles in the marginal carina than there are flank ribs (in *S. kensleyi* they are almost equal), a more prominent median longitudinal furrow, and lacks the coarse tuberculation of the escutcheon seen in *S. kensleyi*. Moreover, the transverse

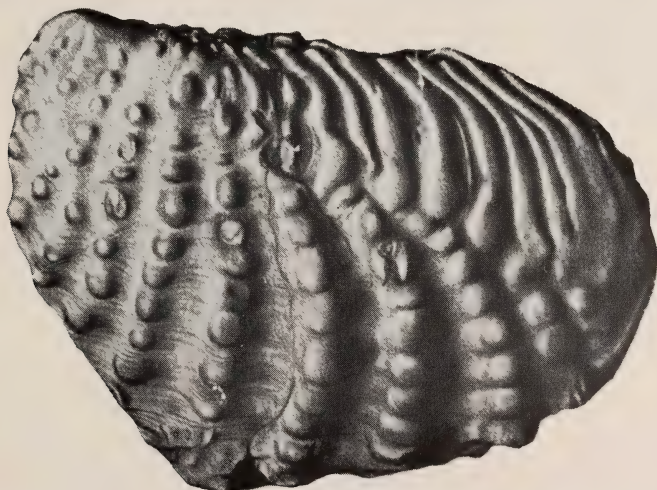


Fig. 9. *Steinmanella* (*Steinmanella*) *mamillata* (Kitchin). The holotype from the uppermost Tithonian or Berriasian of southern India. After Kitchin (1903).  $\times 1$ .

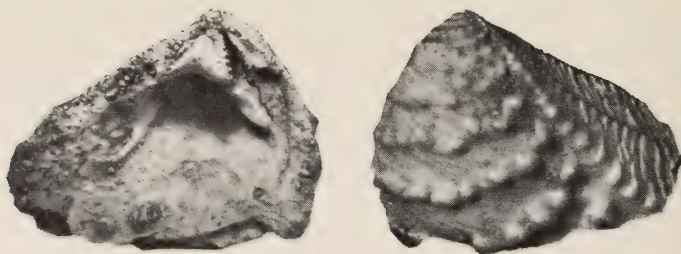


Fig. 10. *Myophorella bronni* (Agassiz). Left valve of SAM-D1622, from the Aptian of Perte-du-Rhône, France.  $\times 1$ .

ridges across the area of *T. bronni* are far more weakly developed than in the Brenton species.

*Steinmanella neuquensis* (Burckhardt) (Fig. 11) also bears a close general resemblance to *S. kensleyi*. It differs, however, in lacking the fine concentric ribbing of the nepionic stages seen in the latter species, and in lacking the prominent tuberculation of the escutcheon. Furthermore, this Lower Cretaceous (Berriasian) South American species lacks the rows of tubercles demarcating the marginal and inner carinae, and the median longitudinal furrow of



Fig. 11. *Steinmanella neuquensis* (Burckhardt). The holotype from the Berriasian of Argentina. After Burckhardt (1903).  $\times 0,75$ .



*S. kensleyi*, while Burckhardt's species also has finer, more prominent transverse ridges across the area, which extend noticeably on to the flanks.

*Steinmanella holubi* (Kitchin) (Fig. 12) is a lower Cretaceous (late Valanginian) species which closely approaches *S. kensleyi*, but differs in being much larger, with a more quadrate outline, and in having most of the flank costae terminating along the ventral margin of the shell. *Steinmanella herzogi* (Goldfuss), *S. hennigi* (Lange) and *S. transitoria* (Steinmann) are all Neocomian forms which differ so greatly from the present species as not to warrant comparison.

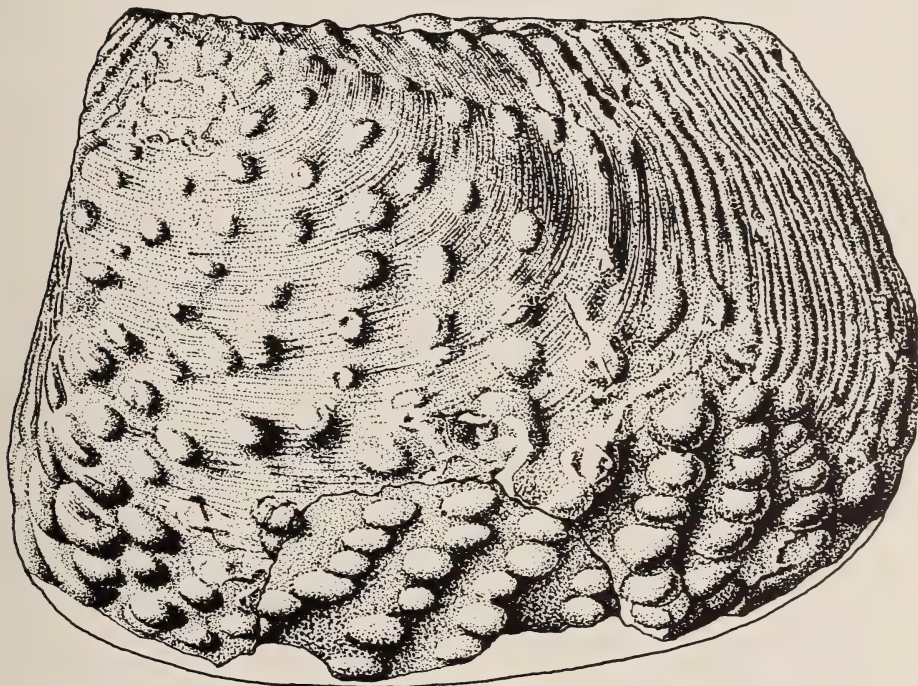


Fig. 12. *Steinmanella* (*Steinmanella*) *holubi* (Kitchin). The holotype from the uppermost Valanginian of south-east Africa. After Kitchin (1908).  $\times 1$ .

#### AGE OF THE FAUNA

The marine succession at Brenton-on-Lake, Knysna, is of very limited thickness and unless there is considerable condensation, which has not been detected, it seems most unlikely that more than one stage is involved.

The ostracod fauna recorded by Dingle (*in* Dingle & Klinger 1972) came from unit IV of the Brenton succession and was considered to have strong



Callovian affinities, although the fauna was entirely new and hence such a determination can be regarded only as tentative. However, McLachlan *et al.* (1976) have recently revised the ostracod fauna which, together with the foraminifera, has been shown to have many species in common with the Sundays River Formation and is considered, therefore, to be of uppermost Valanginian age. This determination was supported by the studies of Stapleton & Beer (1976) who, on the basis of 50 species of palynomorphs, 5 species of calcareous nannofossil and 12 species of foraminifera, were led to correlate the Brenton Formation with the upper part of the Sundays River Formation, thereby suggesting a late Valanginian age. In addition to this, the presence of the foraminifera *Lagena houteriviana houteriviana* Bartenstein & Brand and *Tristix acutangulus* (Reuss) had led Beer (1972) to suggest an Hauterivian age for the Brenton Formation, whilst the presence of *Marginulina constantia* (Cushman) and *Citharina cf. cristellarioides* (Reuss) were used by Rigassi & Dixon (1972) to suggest a Cretaceous age for this unit.

Bate (1975) has recently described a Middle Callovian ostracod fauna from the Mandawa Anticline of Tanzania which supposedly includes two of the Brenton species, viz. *Cytherella knysnaensis* Dingle and *Cytherelloides brentonensis* Dingle. However, the Tanzanian record of *C. brentonensis* is based upon a single specimen which was said to differ from the holotype in lacking marginal dentition and it was perhaps premature, therefore, to assign it, without reservation, to Dingle's species. As regards species of *Cytherella*, Bate (1975) considered the carapace outline to be the most diagnostic feature, yet, in the author's opinion, *C. mandawaensis* Bate (1975, pl. 1 (figs 3–9)) is as close to the holotype of *C. knysnaensis* as is the example of *C. knysnaensis* figured by Bate (1975). Consequently, the writer is inclined to treat the above determinations with some scepticism.

From within a nodule, presumably from unit IV, came the ammonite referred by Kitchin (1908) to the Lower Hauterivian genus *Acanthodiscus* and by Spath (1930) to the Valanginian-Hauterivian genus *Distoloceras*. Klinger *et al.* (1972), however, assigned this specimen to *Hybonoticeras aff. hildebrandti* (Beyrich), for which they assigned a late mid-Kimmeridgian age, a determination surely influenced by Dingle's ostracod work.

The trigoniid fauna described herein is a typically Cretaceous assemblage, with neither *Steinmanella* nor *Pterotrigonia* being known prior to the uppermost Tithonian or Berriasian and, in view of the recent microfaunal evidence, provides strong support for a late Valanginian age for the Brenton Formation. This is enhanced by the presence of *Iotrigonia cf. vau* (Sharpe), a species known only from the uppermost Valanginian of the Uitenhage basin. Moreover, *Pterotrigonia etheridgei* (Lycett) is known only from the Neocomian to Aptian of southern England and also indicates a Cretaceous age for the Brenton Formation. It is perhaps also significant that the Robberg Formation, the deposition of which was related (Cooper 1974) to the same transgression that deposited the Brenton Formation, has yielded *Megatrigonia cf. conocardiiformis*

(Krauss) a species also known from the Sundays River Formation, although in this respect it should be noted that Da Silva (1966) has also recorded this species from the Jurassic of Mozambique and it is, therefore, long-ranging.

At present, the only problem as regards a late Valanginian age for the Brenton Formation and direct correlation with the Sundays River Formation is the determination of the ammonite fragment. This specimen is entirely septate and represents about one-quarter of a whorl which, according to Klinger *et al.* (1972), shows the following features: 'The whorl section is slightly depressed, subpolygonal. Simple primary ribs bear umbilical and large ventrolateral nodes from which ribs bifurcate or trifurcate and cross the venter with a distinct concave-adoral arch. An impression of the venter of the previous whorl is impressed in the dorsum of this fragment and shows a deep, fairly broad siphonal groove bordered by beaded keels.'

A possibly significant feature of this fragment, not mentioned by Klinger *et al.* (1972), is the two subparallel simple ribs at the adoral end of the fragment which have the appearance of the parabolic ribs which border constrictions in many species of ammonite. The genus *Neohoploceras* was introduced by Spath (1939: 105) for: 'rather inflated Neocomitids, with deep constrictions and rib-bundles, starting from umbilical tubercles and bearing lateral tubercles higher up, also single ribs without tubercles between, and specialized ribs, preceding the constrictions, and tuberculate each side of the smooth or grooved siphonal line. The lateral tubercle may disappear on outer whorl. Suture line fairly simple, with asymmetrical first lateral lobe.'

This generic diagnosis covers almost every feature shown by the Brenton ammonite fragment and, in view of the fact that *Neohoploceras* is a characteristic and abundant ammonite in the Upper Valanginian of Madagascar, as well as its occurrence in the Sundays River Formation, viz. *Neohoploceras subanceps* (Tate), together with the microfaunal and trigoniid evidence, the writer considers the determination of Klinger *et al.* (1972) to be incorrect. This fragment is best referred to, therefore, as *Neohoploceras* sp.

It would seem, therefore, that the Brenton and Robberg formations are further deposits whose deposition can be related to the late Valanginian episode of eustatic transgression (Cooper 1974, 1977).

### SUMMARY

The trigoniid fauna from the Brenton Formation is described and fully corroborates recent microfaunal evidence for a Cretaceous age for the Brenton Formation. Although the trigoniids cannot be used precisely to date the deposit, the presence of *Iotrigonia* cf. *vau* (Sharpe) in the Brenton Formation and *Megatrigonia* cf. *conocardiiformis* (Krauss) in the Robberg Formation, the deposition of which was considered to be coeval with sedimentation of the Brenton Formation (Cooper 1974), certainly supports the late Valanginian age suggested by microfaunal evidence. The presence of the Kimmeridgian ammonite *Hyboniticeras* is considered to be based upon the misidentification of the late

Valanginian genus *Neohoploceras*. Two new species, *Steinmanella kensleyi* and *Pterotrigonia savagei*, are described, and the macrofaunal list from the Brenton Formation now reads:

*Steinmanella* (*Steinmanella*) *kensleyi* sp. nov.

*Pterotrigonia etheridgei kitchini* (Schwarz)

*Pterotrigonia savagei* sp. nov.

*Iotrigonia* cf. *vau* (Sharpe)

*Isognomon theseni* (Schwarz)

*Isognomon brentonensis* (Schwarz)

*Neohoploceras* sp.

*Hibolites* sp.

'*Nautilus*' sp.

### ACKNOWLEDGEMENTS

I am grateful to Dr B. F. Kensley and Mrs J. Hosford for their help in the field, and to Dr N. J. Morris of the British Museum (Natural History) for showing me material in that museum and for reading the manuscript. My special thanks go to Mr R. Oosthuizen of Zwartskraal, Prince Albert, to whose diligent collecting I owe much of the material described here.

### REFERENCES

- BATE, R. H. 1975. Ostracods from Callovian to Tithonian sediments of Tanzania, East Africa. *Bull. Br. Mus. nat. Hist. (Geol.)* **26**: 163–223.
- BEER, E. M. 1972. Note in: *Ann. geol. Surv. Pretoria* **9**: 25.
- BURCKHARDT, C. 1903. Beiträge zur Kenntniss der Jura- und Kreideformation der Cordillere. *Palaeontographica* (B) **50**: 1–144.
- COOPER, M. R. 1974. The Cretaceous stratigraphy of south-central Africa. *Ann. S. Afr. Mus.* **66**: 81–107.
- COOPER, M. R. 1977. Eustacy during the Cretaceous: its implications and importance. *Palaeogeogr. Palaeoclima. Palaeoecol.* **22**: 1–60.
- COX, L. R. 1969. Family Trigoniidae. In: MOORE, R. C., ed. *Treatise on invertebrate paleontology* Part N (1), Mollusca 6, Bivalvia. Lawrence: Geological Society of America, University of Kansas Press.
- DINGLE, R. V. & KLINGER, H. C. 1972. The stratigraphy and ostracod fauna of the Upper Jurassic sediments from Brenton, in the Knysna outlier, Cape Province. *Trans. R. Soc. S. Afr.* **40**: 279–298.
- DU TOIT, A. L. 1954. *The geology of South Africa*. Edinburgh: Oliver & Boyd.
- HOEPEN, E. C. N. VAN. 1929. Die krytfauna van Soeloeland. I. Trigoniidae. *Paleont. Navors. nas. Mus. Bloemfontein* **1**: 1–38.
- JONES, D. L. 1960. Pelecypods of the genus *Pterotrigonia* from the west coast of North America. *J. Paleont.* **34**: 433–439.
- KITCHIN, F. L. 1903. The Jurassic fauna of Cutch. The Lamellibranchiata. Genus *Trigonia*. *Mem. geol. Surv. India Palaeont. indica* **9** 3(2): 1–122.
- KITCHIN, F. L. 1908. The invertebrate fauna and palaeontological relationships of the Uitenhage Series. *Ann. S. Afr. Mus.* **7**: 21–225.
- KLINGER, H. C., KENNEDY, W. J. & DINGLE, R. V. 1972. A Jurassic ammonite from South Africa. *Neues Jb. Geol. Paläont. Mh.* **11**: 653–659.
- LYCETT, J. 1872–1879. A monograph of the British fossil trigoniinae. *Palaeontogr. Soc. [Monogr.]*: 1–52 (1872); 53–92 (1874); 93–148 (1875); 149–204 (1877); 205–245 (1879).
- McLACHLAN, I. R., BRENNER, P. W. & McMILLAN, I. K. 1976. The stratigraphy and micro-palaeontology of the Cretaceous Brenton Formation and the PB-A/1 well, near Knysna, Cape Province. *Trans. geol. Soc. S. Afr.* **79**: 341–370.



- NAKANO, M. 1974. *Rinetrigonia* and its allies. *J. Sci. Hiroshima Univ. (C)* 7: 101–111.
- PRINGLE, J. A. 1960. A new species of *Trigonia* from the Sunday's River Beds of the Uitenhage Series, Cape Province. *Ann. Natal. Mus.* 15: 89–92.
- RENNIE, J. V. L. 1936. Lower Cretaceous Lamellibranchia from northern Zululand. *Ann. S. Afr. Mus.* 31: 277–391.
- RIGASSI, D. A. & DIXON, G. 1972. Cretaceous of the Cape Province, Republic of South Africa. *Ibadan Univ. Conf. on Afr. Geol.* 1970: 513–527.
- ROGERS, A. W. 1909. Notes on a journey to Knysna. *Rep. geol. Commn Cape Good Hope* 1908: 130–134.
- SCHWARZ, E. H. L. 1906. Geological survey of the coastal plateau in the division of George, Knysna, Uniondale and Humansdorp. *Rep. geol. Commn Cape Good Hope* 1905: 47–94.
- SCHWARZ, E. H. L. 1915. New Cretaceous fossils from Brenton, Knysna. *Rec. Albany Mus.* 3: 120–126.
- SHARPE, D. 1856. Description of fossils from the secondary rocks of Sundays River and Zwartkops River, South Africa. *Trans. geol. Soc. Lond.* (2) 7: 193–215.
- SILVA, G. H. DA. 1966. Sobre a ocorrência do Jurássico marinho no norte de Moçambique. *Revta Estud. ger. Univ. Moçambique* 3(2): 61–68.
- SPATH, L. F. 1930. On the Cephalopoda of the Uitenhage Beds. *Ann. S. Afr. Mus.* 28: 131–157.
- SPATH, L. F. 1939. The Cephalopoda of the Neocomian Belemnite Beds of the Salt Range. *Mem. geol. Surv. India Palaeont. indica n.s.* 25: 1–154.
- STAPLETON, R. P. & BEER, E. M. 1976. 'Upper Jurassic' sediments of South Africa. *Nature, Lond.* 264: 49.
- STOYANOW, A. 1949. Lower Cretaceous stratigraphy in southeastern Arizona. *Mem. geol. Soc. Am.* 38: 1–169.
- YEHARA, S. 1923. Cretaceous Trigoniae from southwestern Japan. *Jap. J. Geol. Geogr.* 2: 59–84.









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Family Nuculanidae

*Nuculana (Lembulus) bicuspidata* (Gould, 1845)

Figs 14–15A

*Nucula (Leda) bicuspidata* Gould, 1845: 37.

*Leda plicifera* A. Adams, 1856: 50.

*Laeda bicuspidata* Hanley, 1859: 118, pl. 228 (fig. 73). Sowerby, 1871: pl. 2 (fig. 8a–b).

*Nucula largillierii* Philippi, 1861: 87.

*Leda bicuspidata*: Nicklès, 1950: 163, fig. 301; 1955: 110. Barnard, 1964: 234, figs 8–9.

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MICHAEL R. COOPER

CRETACEOUS TRIGONIIDAE  
(MOLLUSCA, BIVALVIA) FROM THE  
BRENTON FORMATION, KNYSNA

07.68

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# ANNALS

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- FISCHER, P.-H. 1948. Données sur la résistance et de la vitalité des mollusques. *J. Conch.*, Paris 88: 100-140.
- FISCHER, P.-H., DUVAL, M. & RAFFY, A. 1933. Études sur les échanges respiratoires des littorines. *Archs Zool. exp. gén.* 74: 627-634.
- KOHN, A. J. 1960a. Ecological notes on *Conus* (Mollusca: Gastropoda) in the Trincomalee region of Ceylon. *Ann. Mag. nat. Hist.* (13) 2: 309-320.
- KOHN, A. J. 1960b. Spawning behaviour, egg masses and larval development in *Conus* from the Indian Ocean. *Bull. Bingham oceanogr. Coll.* 17 (4): 1-51.
- THIELE, J. 1910. Mollusca: B. Polyplacophora, Gastropoda marina, Bivalvia. In: SCHULTZE, L. *Zoologische und anthropologische Ergebnisse einer Forschungsreise im westlichen und zentralen Süd-Afrika* 4: 269-270. Jena: Fischer. *Denkschr. med.-naturw. Ges. Jena* 16: 269-270.

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INDICATOR COPEPODS AND OIL YIELD  
FLUCTUATIONS IN PELAGIC FISH IN  
THE BENGUELA CURRENT SYSTEM

By  
A. H. B. DE DECKER  
&  
D. J. COETZEE

Cape Town Kaapstad



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# INDICATOR COPEPODS AND OIL YIELD FLUCTUATIONS IN PELAGIC FISH IN THE BENGUELA CURRENT SYSTEM

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(With 4 figures)

[MS. accepted 7 March 1979]

## ABSTRACT

The decline in the catches of the South West African pelagic fishery is paralleled by a declining trend in the oil yield (i.e. the ratio, fish oil to fish meal). Depressions in the oil yield show inverse correlation with the southward extension over the South West African shelf of a warm, saline water mass carrying the neritic copepods *Temora turbinata* and *Euterpina acutifrons*. In the region of north-west deflection of the Benguela waters, *T. turbinata* can be carried seaward over distances exceeding 250 nautical miles off shore.

Although fragmentary, the environmental data point towards a strong influence of abiotic factors on the abundance and condition of the available pelagic stocks.

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## INTRODUCTION

Based initially on the pilchard (*Sardinops ocellata*), the South West African pelagic fishery once ranked among the most important in the world. From the middle sixties onward, a few short-lived depressions were experienced and from 1970, after the anchovy (*Engraulis capensis*) had become a regular component of the catches (up to 27% in 1970, increasing to 41% in 1973, according to official statistics), the total pelagic landings at Walvis Bay showed as spectacular a decline as their rise had been in the early sixties. Such a succession of events is not unique in the history of fisheries.

\* Present address: Dept. of Nature and Environmental Conservation of the Cape Province, Cape Town.

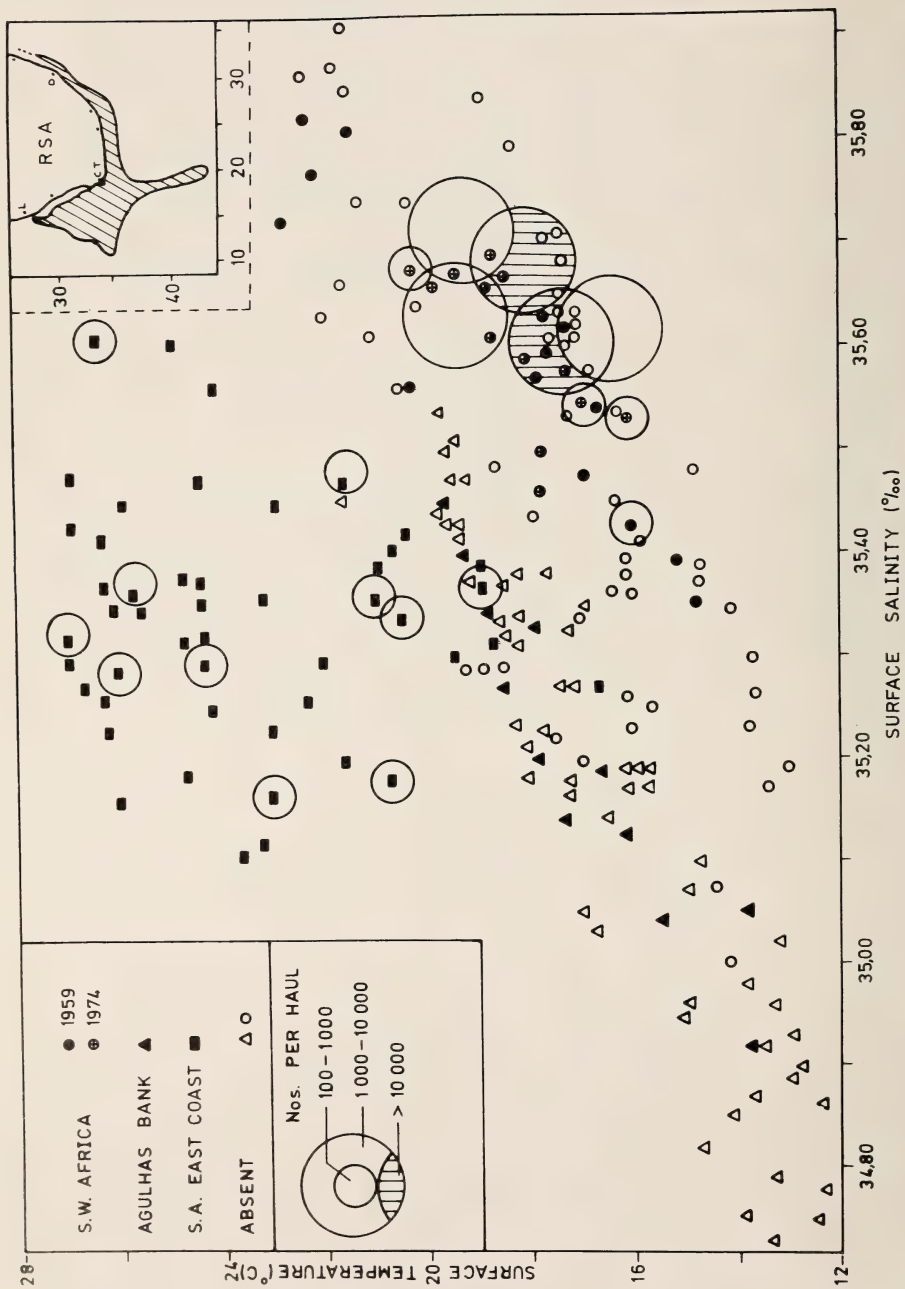


Fig. 1. T/S diagram of surface waters and occurrence of *Temora turbinata* around South and South West Africa.  
Inset: distribution of *T. turbinata* around South Africa.

The first serious alarm shook the local fisheries circles in 1963, when the oil yield of the pilchard missed its annual winter peak and stayed at minimum levels throughout the fishing season. Apart from this low oil yield, survey data revealed greatly reduced gonad development, virtual absence of eggs in the usual spawning grounds and abnormally high water temperatures and salinities. The plankton showed notable differences in density distribution and species composition from what Unterüberbacher (1964) had observed during a year-round monthly survey of the same area in 1961–2. Stander & De Decker (1969) attempted an interpretation of these physical and biological changes, using in the latter category what little is known about the biogeography of copepods in the south-eastern Atlantic.

Subsequent plankton studies in South West African waters indicated a correlation between the distribution and abundance of the copepod *Temora turbinata* and the annual oil yield cycle of the pelagic fish landings at Walvis Bay. These findings are the subject of the present report.

*Temora turbinata* is a neritic epipelagic copepod of tropical and subtropical waters of the Atlantic and Indo-Pacific where it is widespread and often predominant inshore. It has a wide salinity and temperature tolerance, but does not appear to subsist at temperatures below 15°C (Bradford 1977). Its distribution along the Atlantic coast of Africa is well documented through the work of a number of planktologists whose respective survey localities are spaced along the entire western coastline of the continent. An account of most of these contributions has been published by Thiriot (1977).

It appears to be present nearly everywhere in inshore waters, except where upwelling prevails, especially along the south-western and north-western coast. The contrast between the copepod assemblages in a habitat where *T. turbinata* predominates and one where it is excluded through upwelling is well illustrated by the examples of the Angolan neritic facies (Neto & De Paiva 1966) and the Walvis Bay area (Unterüberbacher 1964). In the former, 73% of the planktonic copepods consisted of *Oithona nana* (37%), *T. turbinata* (22%) and *Euterpina acutifrons* (14%), whereas the latter had 48% composed of *Centropages brachiatus* (18%), *Calanoides carinatus* (15%) and *Metridia lucens* (15%).

The full range of salinity and temperature records for *T. turbinata* around southern Africa is presented in Figure 1, based on the authors' unpublished data. The copepod adapts to the complete range of salinities prevailing in the various neritic environments encountered around the subcontinent, in temperatures between 14° and 28°C. Higher temperatures were not recorded in the neritic zone and it is, therefore, questionable whether 28°C is the upper limit for *T. turbinata*.

## MATERIAL AND METHODS

The data discussed here were obtained from the following sources.

1. Survey Area A (see Fig. 2: April 1959). Nine quarterly surveys of a 240 nautical mile wide belt stretching from the Cape of Good Hope to Kunene



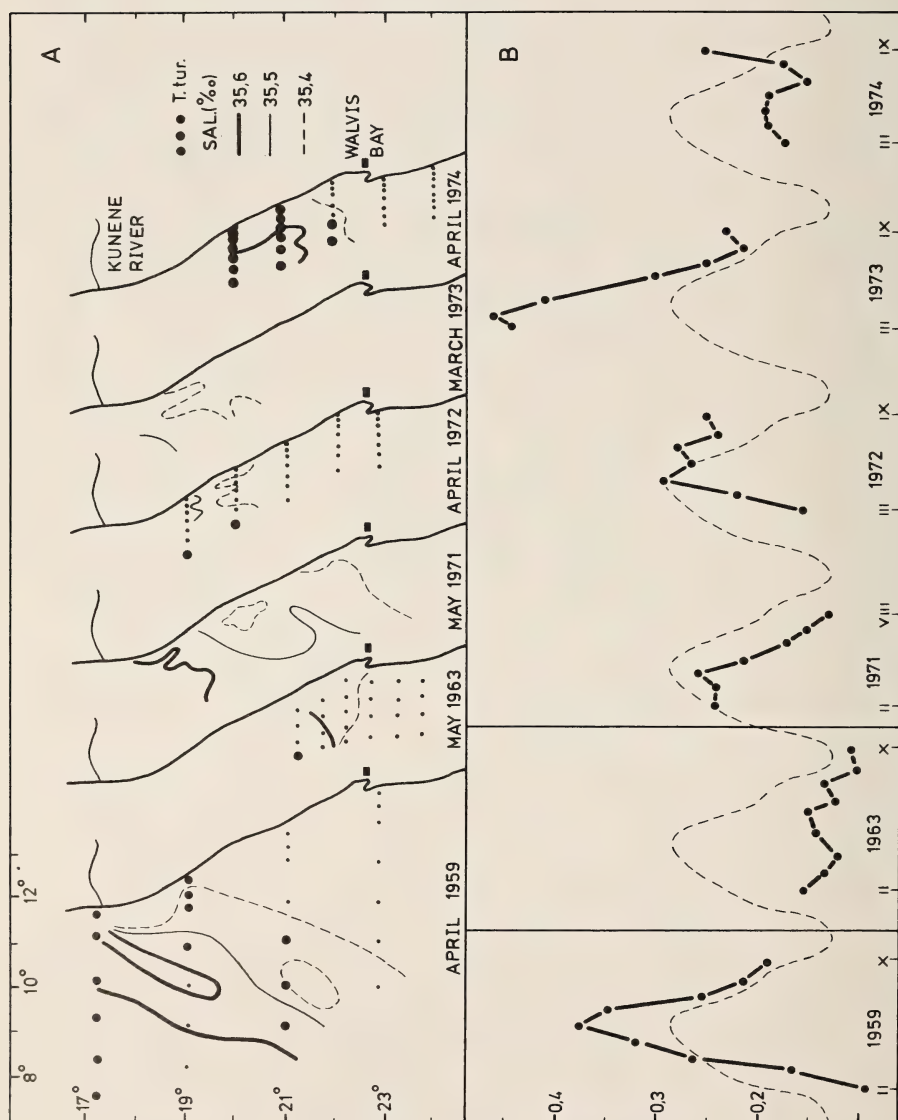


Fig. 2. A. Surface isohalines and occurrence of *Temora turbinata*. B. Oil yield fluctuations in pelagic catches (dotted line = average for 1965-1974).

River mouth (17°S) in January, April, July, October 1959, and January 1960, but to Ambrose Bay only (21°S) in April, July, October 1960, and January 1961. On these cruises, plankton was collected by means of a N70 net hauled vertically from 100 m to the surface—or bottom to surface where the sounding was less than 100 m. A total of 168 samples was examined.

2. Survey Area B (see Fig. 2: May 1963). Nineteen monthly surveys of a 90 nautical mile wide coastal belt between 21° and 24°S. The samples collected between April 1961 and March 1962 were studied by Unterüberbacher (1964) and those from December 1962 to August 1963 by Stander & De Decker (1969). The method of collection was the same as in Area A, and a total of 475 samples was examined.

3. Survey Area C (see Fig. 2: April 1972 to April 1974). A coastal belt of 50–70 nautical miles wide surveyed in the early seventies at irregular intervals and with varying station grids. The part stretching northward from Walvis Bay was examined for zooplankton taken on the following cruises: January, April, June, August and October 1972, and April 1974. A WP2 net was hauled vertically from a maximum depth of 200 m to the surface. A total of 108 samples was examined.

4. Statistics on pelagic fish landings at Walvis Bay and monthly oil yields from 1950 to 1977, except during closed seasons.

Areas A and C were surveyed by the Division of Sea Fisheries (later styled Sea Fisheries Branch, Cape Town), and Area B by the Marine Research Laboratory, Walvis Bay.

The plankton samples were examined under a stereomicroscope for identification and counting of species. Bulky samples were split to a convenient aliquot by means of a Folsom splitter, but the whole sample was then scanned for species not represented in the aliquot. The samples examined are housed in the plankton collections of the Sea Fisheries Branch, Cape Town.

Salinities in Areas A and B were estimated by the Knudsen method, in Area C by inductive salinometer, using water samples obtained with a Nansen Petterson bottle, which also provided the temperature readings.

## RESULTS

### *Temora turbinata* as an indicator

Although present in less than 5 per cent of the samples, *T. turbinata* drew the attention of both the present authors independently by its way of appearing suddenly in large numbers in a few samples, each time in the north of the survey areas. There is an indication of seasonality (January to May) which agrees reasonably with the peak of abundance of this species in Angolan waters (Neto & De Paiva 1966) and with the season of greatest activity of the Angola Current (Kuderski 1967).

The occurrences can be summarized as follows:

	Jan. '59	Apr. '59	May '63	Apr. '72	Apr. '74
Samples with <i>T. turbinata</i>	5	13	1	2	15
Total of specimens ..	32	853	1	6	174 400
N-limit of survey ..	17°S	17°S	21°S	19°S	20°S
S-limit of <i>T. turbinata</i> ..	19°S	21°S	21°S	20°S	22°S

The numbers of specimens caught on each occasion cannot be compared, due to the great differences in size and station spacing of the survey areas.

Salinity sections soon revealed that *T. turbinata* follows the 35,4‰ isohaline as it moves south and eastward into areas normally occupied by less saline waters typical of the Benguela system (Stander 1964). The waters with salinities in excess of 35,4‰ have a T/S diagram agreeing closely with that of the inshore station on the Angolan shelf off Lucira (13°51'S) monitored daily over a 4-year period (Berrit & Dias 1977) and fall within the range found in Baía Farta (12°36'S) by Neto & De Paiva (1966) and further south by Nümann (1953).

A plankton feature emphasizing the connection between Angolan shelf water and the saline water spreading *T. turbinata* over the whole width of the survey areas, is the presence of another dominant copepod of the Angolan shelf, *Euterpina acutifrons*. This species was unusually abundant in April 1974, when a total of 12 300 specimens was found at 14 stations distributed in a similar pattern to the 174 400 *T. turbinata* collected during that month. (Note: incidental attention only was given to *E. acutifrons* in the present context, because the likelihood of escapement of this small animal through the 200 µm meshes introduces an unknown bias in the catches. The *Oithonas* in our samples were not identified to species, therefore the presence or absence of *Oithona nana*, the most common copepod in Angola, has not been established.)

During the extensive surveys of January and April 1959, *T. turbinata* was found scattered offshore as far as the most distant stations, i.e. over 200 nautical miles beyond the shelf edge (Fig. 2). Very few instances could be found in literature where this neritic organism occurred at significant distances beyond the shelf. One is in the region of Dakar, where the Canaries Current curves away from the continent, with concomitant coastal upwelling: here Khromov (1973) found *T. turbinata* spread as far as 150 nautical miles offshore on one occasion. Another is in the Tasman Sea, where Bradford (1977) found it in large numbers in a sample taken 555 km (300 nautical miles) from the Australian coast in the path of a zonal jet originating from the East Australian Current. In a third example (from the authors' unpublished data), *T. turbinata* hugs the east coast of South Africa to East London, then fans out over the Agulhas Bank before spreading into the open Atlantic to about 35°S, 10°E (i.e. 360 nautical miles west of the Cape of Good Hope) but also follows the southward branch of the Agulhas Current as far as 43°S (i.e. 600 nautical miles due south of the Cape, staying all the way in salinities exceeding 35,45‰ and temperatures over 20°C (Fig. 1: inset).

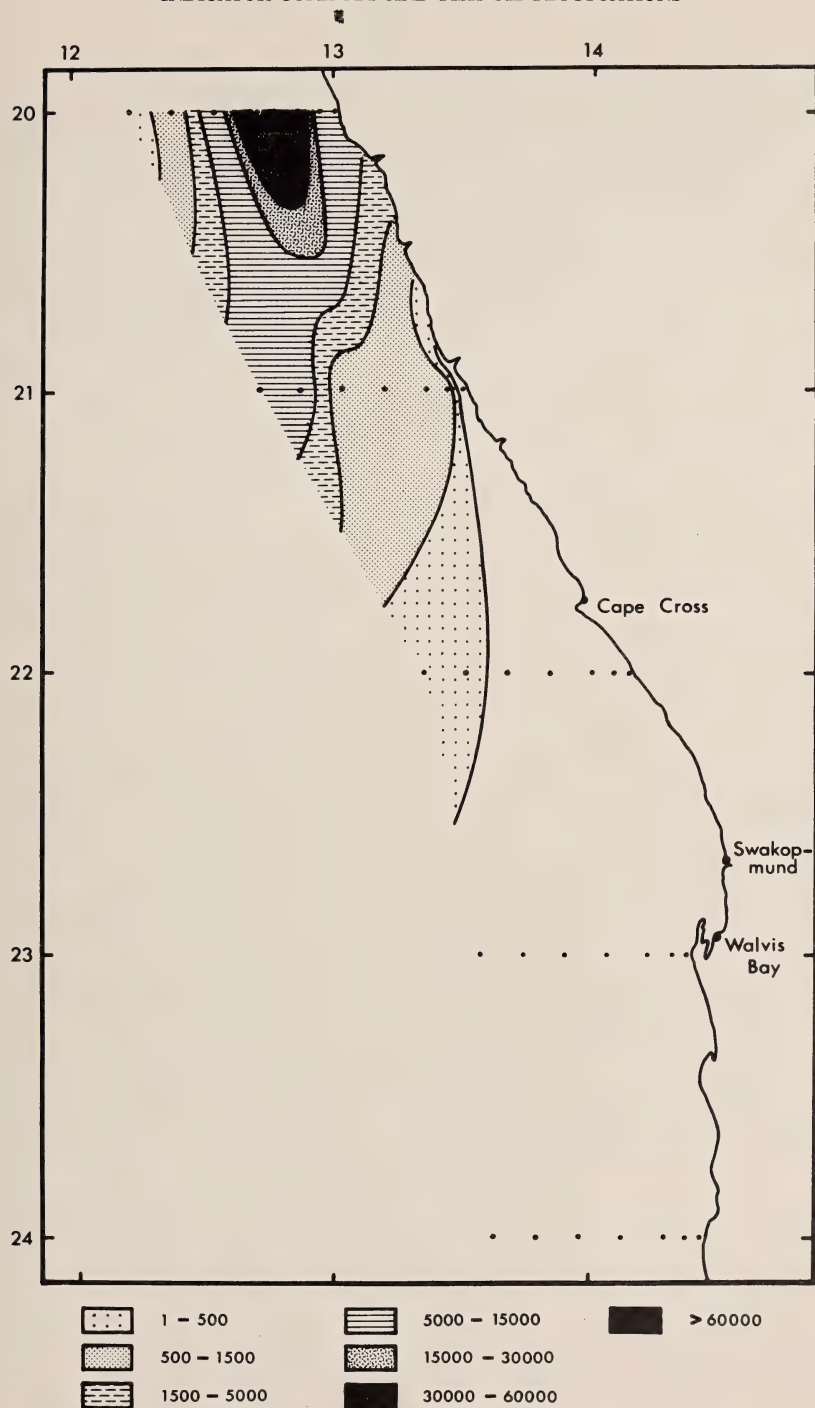


Fig. 3. Distribution of *Temora turbinata* (numbers/net haul) during April 1974.



The obvious indicator quality of *T. turbinata* may prove of practical value to physical and fisheries oceanographers in their attempts at interpreting the dynamics of the zone of interaction between the westward-curving Benguela Current and the water masses confronting it (Elizarov 1967; Kuderski 1967; Kornilova 1967; Moroshkin *et al.* 1970; Filippov & Kolesnikov 1971).

### *Oil Yield Fluctuations*

In spite of an unfortunate lack of continuity and uniformity in environmental monitoring of the South West African waters, especially during the critical years immediately before and during the decline of the pelagic fishery, the fragmentary data available show a parallelism between the environmental events and the vicissitudes of the pelagic stocks.

Arguing that the oil content of a fish gives a good indication of its physiological condition, Schülein (1976) has presented a diagram of the monthly oil yields of the pelagic fish landed at Walvis Bay between 1961 and 1974, later expanded to 1950–77 (pers. comm.). The oil yield is given as the ratio fish oil/fish meal (w/w), and plotted against the background of the average monthly oil yield for the period 1965–74. Excerpts from this diagram are used in Figure 2 to illustrate the correlation between the position of the isohalines, the presence/absence of *T. turbinata* and the oil yield in a number of cases.

During the oil yield depression of 1963 (Stander & De Decker 1969), already mentioned in the introduction, the height of the anomaly was characterized by a strong haline front (35,4–35,6‰) lying just inside the northern limit of the survey area in about 21°S. This front stood nearly vertically throughout the upper 50 m, separating a core of 20°C from Benguela water of 15°C and less. One single specimen of *T. turbinata* was found to the north of the front and overlooked in the discussion by Stander & De Decker, for obvious reasons. The 174 400 Temora found south of 20°S in April 1974 at 15 stations were a more obtrusive element (Figs 2–3), which caused us to compile all available records on *T. turbinata* in South West African waters and on thermohaline conditions in the area north of the latitude of Walvis Bay, regardless of the availability of concomitant plankton data.

During that April 1974 survey, the 35,4‰ isohaline reached as far south as 22°S, with that of 35,6‰ following in 21°20'S—no frontal condition by local standards. Two months earlier, however, in February, a strong front had suddenly appeared between 19°10' and 19°30'S, bundling the isohalines from 35,4 to 35,9‰, the 35,4‰ isohaline reaching the shore in 20°S. In March the off-shore front had progressed southward to 23°S over nearly the whole width of the survey area, reaching the coast in 22°S. At the northern limit of the survey, Cape Frio (18°S), the near-shore salinity was 35,7‰. No plankton samples were available from February or March and our April samples were taken during the receding phase of the saline intrusion. The oil yield in 1974 was nearly as catastrophic as in 1963.

1971 and 1972 were on the lean side as far as oil yield is concerned. No

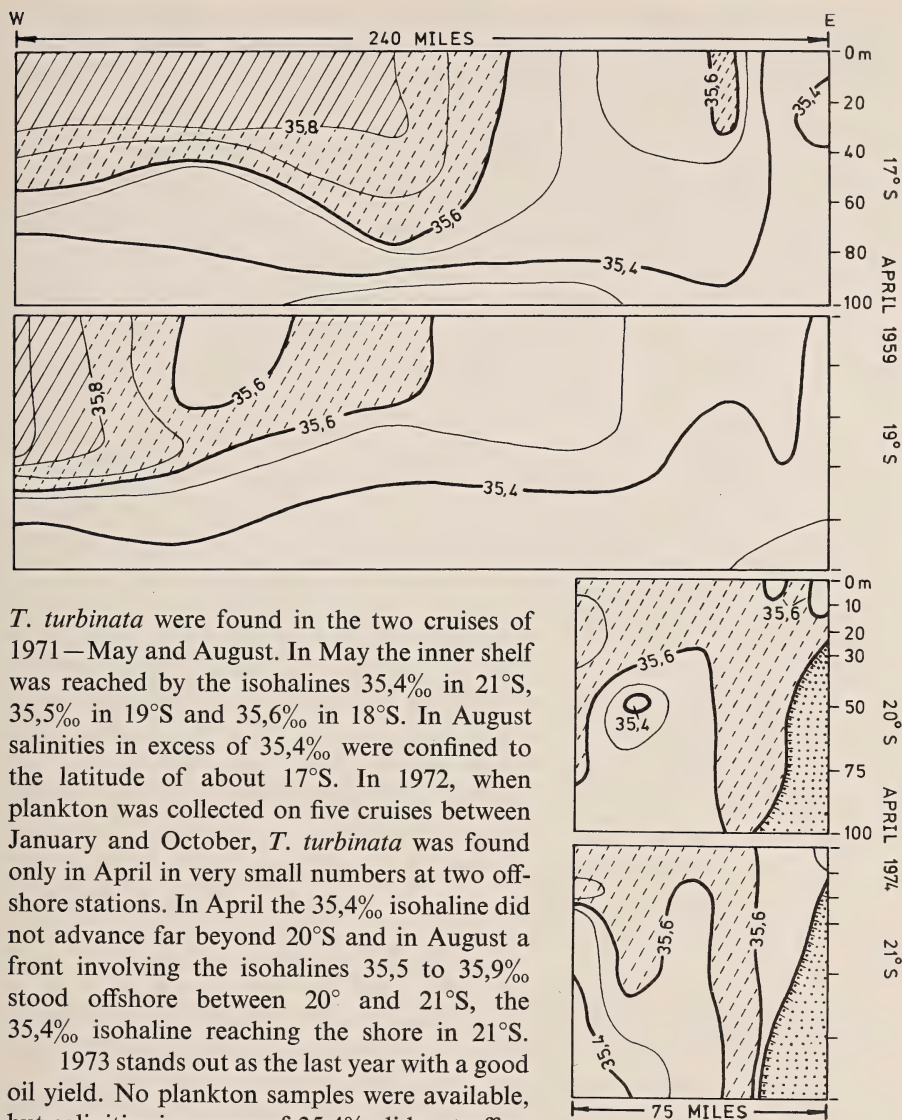


Fig. 4. Vertical sections of salinity for April 1959 and April 1974.

*T. turbinata* were found in the two cruises of 1971—May and August. In May the inner shelf was reached by the isohalines 35,4‰ in 21°S, 35,5‰ in 19°S and 35,6‰ in 18°S. In August salinities in excess of 35,4‰ were confined to the latitude of about 17°S. In 1972, when plankton was collected on five cruises between January and October, *T. turbinata* was found only in April in very small numbers at two off-shore stations. In April the 35,4‰ isohaline did not advance far beyond 20°S and in August a front involving the isohalines 35,5 to 35,9‰ stood offshore between 20° and 21°S, the 35,4‰ isohaline reaching the shore in 21°S.

1973 stands out as the last year with a good oil yield. No plankton samples were available, but salinities in excess of 35,4‰ did not affect the inner shelf significantly further south than 19°S. This situation closely resembles the conditions prevailing in April 1959, i.e. a year with a good oil yield, although *T. turbinata* was present in significant numbers over a large area in the north (Fig. 2) but did not extend over the shelf beyond 19°S. The vertical sections in Figure 4 illustrate the difference in near-shore haline structure between a favourable year (1959) and an unfavourable one (1974).

The disastrous year 1974 was followed by three more years with minimal oil yield resembling that of 1963. Unfortunately, neither hydrological nor planktological data were available to the authors for that period.

### CONCLUSIONS

To sum up, it appears that the yearly oil cycle of the available pelagic stocks in the South West African fishing ground correlates inversely with the volume and southward advance over the inner shelf of a water mass with salinities in excess of 35.4‰, which is related to, or identical with, the Angola Current. This water is marked by the presence of the copepod *Temora turbinata*—at least during the first half of the year.

According to Schüleïn's above-mentioned oil yield diagram for the period 1950–77, 13 consecutive years (1950–62) exceeded the 1965–74 oil yield average, with the only exception of 1957 which was slightly depressed. Then came the 1963 debacle followed by a spectacular upsurge in 1964, when an all-time record yield was reached. The subsequent 13-year period was marked by a steady decline, interrupted by peak years in 1968–70 and 1973, and ending with the 4 consecutive years of minimum yield mentioned above.

This downward trend of the oil yield (which cannot be explained to its full extent by the advent of the less oil-rich anchovy) is paralleled by the dramatic decline of the pelagic catches mentioned in the introduction. To look for a reason for this parallelism falls beyond the scope of the present communication. It is often difficult to establish to what extent the decline of a fishery is due to (over)fishing or to environmental change. In the present instance, however, it seems clear that the environment has played a primary role in the decline, its effects being aggravated by an exploitation policy that did not take the environmental stress into account.

### ACKNOWLEDGEMENTS

The help of Miss E. L. McArdell in the preparation of the illustrations is gratefully acknowledged.

### REFERENCES

- BERRIT, G. R. & DIAS, C. A. 1977. Hydroclimatologie des régions côtières de l'Angola, Description des variations saisonnières à Lobito et Lucira. *Cah. ORSTROM, Océanogr.* **15** (2): 181–196.
- BRADFORD, J. M. 1977. Distribution of the pelagic copepod *Temora turbinata* in New Zealand coastal waters, and possible trans-Tasman population continuity. *N.Z. J. mar. freshw. Res.* **11**: 131–144.
- ELIZAROV, A. A. 1967. Some results of oceanic research in fisheries areas off South West Africa. *Oceanology* **7**: 344–347.
- FILIPPOV, E. A. & KOLESNIKOV, G. I. 1971 (Origin of southward components in the Benguela Current system). *Trudy AtlantNIRO* **33**: 42–49.
- KHROMOV, N. S. 1973 (Distributional features of some dominant copepod species in zones where the northern subtropical circulation of the Atlantic comes in contact with the coasts). In: *Bonitation of the World Ocean* **4**: 81–112 (Trudy VNIRO, 84).
- KORNILOVA, G. M. 1967 (Characteristics of the plankton of the fishing grounds of the Eastern Atlantic in the spring of 1961). *Mater. Konfer. Result. okeanol. Issled. Atlant. Okeane, AtlantNIRO*: 158–171.

- KUDERSKII, S. K. 1967. (Hydrology of the shelf waters off the South West African coast and its influence on the distribution and behaviour of certain commercial fish). *Mater. Konfer. Result. okeanol. Issled. Atlant. Okeane*, AtlantNIRO: 199-209.
- MOROSHKIN, K. V., BUBNOV, V. A. & BULATOV, R. P. 1970. Water circulation in the Eastern South Atlantic. *Oceanology* **10**: 27-37.
- NETO, T. S. & PAIVA, I. DE. 1966. Ciclo anual do zooplankton colhido na Baía Farta em 1960. *Notas mimeogr. Cent. Biol. aquat. trop.* **2**: 1-62.
- NÜMANN, W. 1953. Campanhas em Angola. Estudos de química e física do meio marinho. *Trab. Miss. Biol. marít.* **1**: 33-66.
- SCHÜLEIN, F. H. 1976. The relationship between recruitment and oil yields from pelagic fish. Paper presented at the First Interdisciplinary Conference on Marine and Freshwater Research in Southern Africa, Port Elizabeth, 5-10 July 1976. Mimeographed, 15 pp.
- STANDER, G. H. 1964. The Benguela Current off South West Africa. *Investl Rep. mar. Res. Lab. S.W.Afr.* **12**: 1-43.
- STANDER, G. H. & DE DECKER, A. H. B. 1969. Some physical and biological aspects of an oceanographic anomaly off South West Africa in 1963. *Investl Rep. Div. Sea Fish. Cape Town* **81**: 1-46.
- THIRIOT, A. 1977. Peuplements zooplanctoniques dans les régions de remontée d'eau le long du littoral atlantique africain. *Docum. sci. Centre Rech. océanogr. Abidjan* **8**: 1-72.
- UNTERÜBERBACHER, H. K. 1964. Zooplankton studies in the waters off Walvis Bay with special reference to the Copepoda. *Investl Rep. mar. Res. Lab. S.W.Afr.* **11**: 1-42.









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*Nuculana (Lembulus) bicuspidata* (Gould, 1845)

Figs 14–15A

*Nucula* (*Leda*) *bicuspidata* Gould, 1845: 37.

*Leda plicifera* A. Adams, 1856: 50.

*Laeda bicuspidata* Hanley, 1859: 118, pl. 228 (fig. 73). Sowerby, 1871: pl. 2 (fig. 8a–b).

*Nucula largillierii* Philippi, 1861: 87.

*Leda bicuspidata*: Nickles, 1950: 163, fig. 301; 1955: 110. Barnard, 1964: 234, figs 8–9.

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- FISCHER, P.-H., DUVAL, M. & RAFFY, A. 1933. Études sur les échanges respiratoires des littorines. *Archs Zool. exp. gén.* 74: 627-634.
- KOHN, A. J. 1960*a*. Ecological notes on *Conus* (Mollusca: Gastropoda) in the Trincomalee region of Ceylon. *Ann. Mag. nat. Hist.* (13) 2: 309-320.
- KOHN, A. J. 1960*b*. Spawning behaviour, egg masses and larval development in *Conus* from the Indian Ocean. *Bull. Bingham oceanogr. Coll.* 17 (4): 1-51.
- THIELE, J. 1910. Mollusca: B. Polyplacophora, Gastropoda marina, Bivalvia. In: SCHULTZE, L. *Zoologische und anthropologische Ergebnisse einer Forschungsreise im westlichen und zentralen Süd-Afrika* 4: 269-270. Jena: Fischer. *Denkschr. med.-naturw. Ges. Jena* 16: 269-270.

(continued inside back cover)

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NEW SECTIONS IN THE VARSWATER  
FORMATION (NEOGENE) OF LANGEBAAN ROAD,  
SOUTH-WESTERN CAPE, SOUTH AFRICA

By  
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&  
Q. B. HENDEY

Cape Town Kaapstad



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# NEW SECTIONS IN THE VARSWATER FORMATION (NEOGENE) OF LANGEBAAN ROAD, SOUTH-WESTERN CAPE, SOUTH AFRICA

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(With 6 figures and 1 table)

[MS. accepted 8 March 1979]

## ABSTRACT

Recent excavations in the phosphate mine at Varswater Quarry, Langebaan Road, have exposed horizons in the late Miocene/early Pliocene Varswater Formation higher than any previously recorded. These sections are measured and their lithologies described. They consist of approximately 6 m of interbedded phosphatic sands and phosphate rock, with a non-phosphatic sand layer near the top. The whole sequence is unconformably overlain by Quaternary sands and soils. Although the phosphate rock layers are shown to be laterally impersistent, they locally reach thicknesses of up to 2 m, and represent the most impressive phosphate rock units so far recorded from the Neogene rocks of the western Cape. Previous definitions of the Varswater Formation and the supposedly underlying 'Saldanha Formation' are reconsidered, and the lithostratigraphic type sections of the latter at Hoedjiespunt are remeasured. It is concluded that the original definition of the Saldanha Formation, as a lithostratigraphic unit distinct from the Varswater Formation, cannot be demonstrated with present data, and that the use of the term 'Saldanha Formation' be discontinued.

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## INTRODUCTION

The Neogene deposits of the south-western Cape rest on Precambrian rocks and are most noteworthy for the occurrence of authigenic phosphate rock and pelletal phosphate sand, as well as for an almost uniquely rich vertebrate fauna. Both phosphates and vertebrate fossils are most common in the Saldanha–Langebaan area (Fig. 1), but the Neogene sediments of this region still lack a precise stratigraphy, despite numerous publications dating from Du Toit (1917) onwards. The most commonly used sequence at present is that described by Tankard (1974, 1975*a*), who divided the succession into two formations with type sections at Hoedjiespunt (Saldanha Formation) and the New Varswater Quarry at Langebaan Road (Varswater Formation). These formations have been provisionally dated by Tankard (1974, 1975*a*) as Miocene and Pliocene respectively.

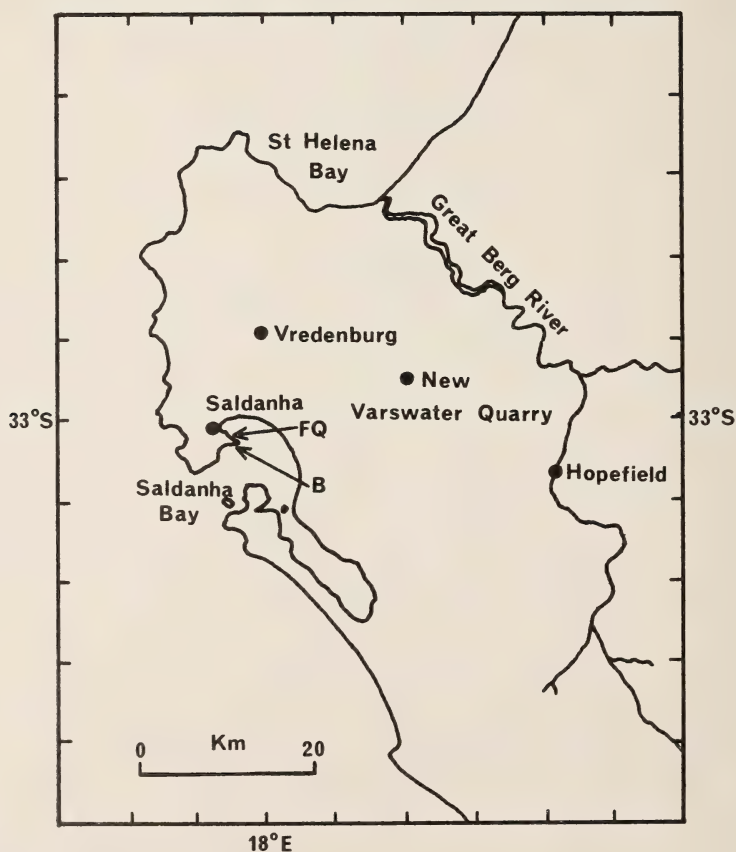


Fig. 1. Location of New Varswater Quarry and outcrops at Hoedjiespunt. FQ—Fishing Quay, B—Bomgat.

The Saldanha Formation is poorly exposed and even the stratotype (Fig. 3 here; Tankard 1975a, fig. 2) at Bomgat, Hoedjiespunt, is ambiguous, consisting of bedded phosphate rock resting on granite and overlain by phosphatic sediment containing rounded boulders and cobbles of granite with Early Quaternary shell sediments above. The upper phosphatic horizon appears to be reworked, although no large phosphate fragments occur in it or in the Quaternary sediments. Neither upper nor lower boundaries of the Saldanha Formation can be recognized in a continuous sedimentary sequence and there is no evidence as to age other than stratigraphic position between a Precambrian granite and Quaternary sediments. On the opposite, northern side of Hoedjiespunt behind the 'Sea Harvest' factory a thin, irregular, discontinuous phosphatic horizon can be recognized between Quaternary sediments and granite, with thin phosphatic veins up to 2 m long infilling joints in the granite (Fig. 3). In the New Varswater Quarry, Tankard (1975a: 260) records the Saldanha Formation as consisting of 1–1.5 m of phosphatic, often conglomeratic, sandstone resting on a soft, silty clay and with the Varswater Formation resting on top with slight angular unconformity. All offshore occurrences of phosphatic rock were included within the Saldanha Formation (Tankard 1975a: 262).

The Varswater Formation is well exposed at the New Varswater Quarry, Langebaan Road, as a result of mining operations for phosphate (Fig. 2). Pelletal phosphate sands with interbedded phosphate rock bands overlie fluvial and estuarine clays, sands and carbonaceous sediments and these deposits contain one of the richest late Tertiary vertebrate faunas in the world (see for example Hendey 1976). This sequence, which is of latest Miocene and/or early Pliocene age (Hendey 1978b), is overlain unconformably by Quaternary aeolian sands and calcretes. The sections revealed by many years of commercial activity have not been accurately recorded and the complex facies relationships of the sediments are inadequately understood. Recent cessation of mining makes publication of some record a matter of urgency as the quarry exposure can only deteriorate. When Tankard (1974) discussed the Varswater Formation, using this quarry as stratotype, the sequence we now record was obviously not available to him, in particular the extensive development of phosphate rock was not apparent.

#### THE SEDIMENTARY SEQUENCE EXPOSED IN THE NEW VARSWATER QUARRY

Here notes based on field observations are given to supplement Figures 3 and 4 which show details of the succession. Note that the terminology is generalized and has no genetic implications; the term 'phosphate rock' is used here for a lithified, phosphate-rich sediment and 'phosphate sands' for unconsolidated or compacted sands with phosphate grains or pellets. No distinction is drawn between the Hoedjiespunt 'microsporite', in Tankard's (1975a) nomenclature, and the phosphate rocks in the New Varswater Quarry which are lithified phosphate sands.



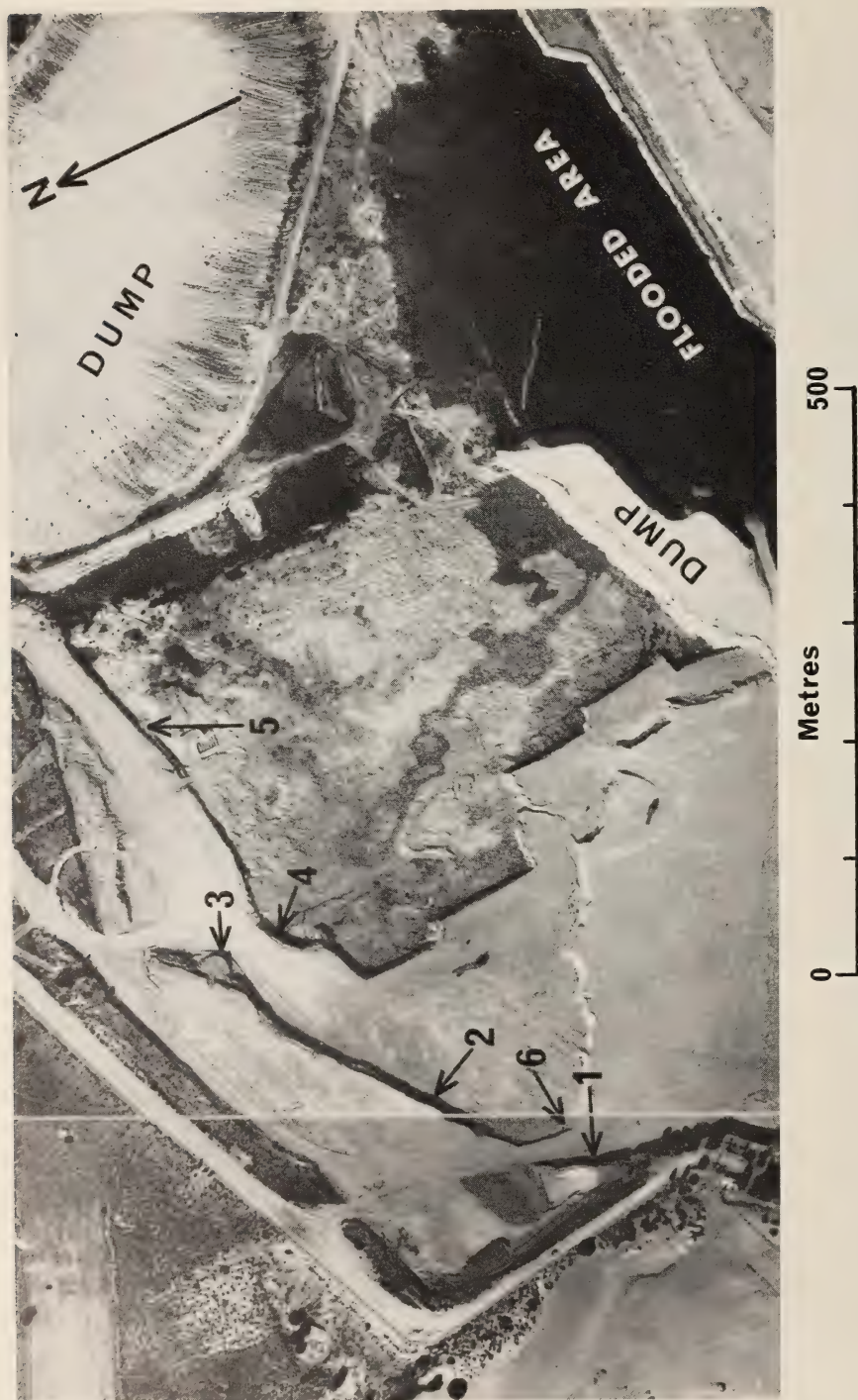


Fig. 2. Aerial photograph of the New Varswater Quarry showing location of numbered exposures in Figures 3 and 4.

## PLEISTOCENE

*Layers A–C.* Bedded calcretes (Layers A, C) separated by a dark-brown soil (Layer B).

*Layer D.* Thick greenish or olive, well-sorted, calcareous quartz sand; strongly cross-bedded in lower 2,5 m while upper 2,9 m contains numerous calcite-filled tubes up to 10 cm diameter.

*Layer E.* Soft, well-sorted, light reddish-brown 'soil'; contains numerous terrestrial gastropods. The junction of Layers D and E is conformable and grades over a short interval (2–5 cm). The lower boundary of Layer E, the local base of the Quaternary, is strongly unconformable on the Varswater Formation and is an erosional surface with numerous small swallow holes. Layer E is discontinuous and varies greatly in thickness.

The Pleistocene succession as a whole is penetrated by numerous long calcite veins which run from the calcretes at the top down into the underlying Varswater Formation. The veining is associated with a late stage of calcite diagenesis, which has also left numerous delicate lace-like structures in the soft sediments of Layers D and E and is the source of the bulk of the calcite matrix in Layer A of the Varswater Formation.

## LATEST MIOCENE/EARLY PLIOCENE

For convenience the Varswater Formation is divided into an upper, phosphatic part (= Pelletal Phosphorite Member of Tankard (1974) and others) and a lower, essentially non-phosphatic part (= Quartzose Sand Member, Gravel Member (Hendey 1976), and beds below (Tankard 1975b)). The Upper Varswater Formation contains pelletal phosphate throughout, whereas the Lower Varswater Formation is phosphate-free apart from the Gravel Member which consists of a phosphatic gravel and sandstone.

*Upper Varswater Formation*

*Layer A.* Phosphate-rich horizon, typically with a massive, discontinuous, basal phosphate rock unit with 'nodules' usually 10–30 cm across. This layer is not reworked. The upper, main part of Layer A consists of a mixture of thinly bedded iron-stained phosphate rock and thinly bedded porcellanous calcrete with a matrix of porous calcareous material which was introduced during the Quaternary via the veins referred to above. The porcellanous calcrete appears to be secondary and the product of weathering prior to, or during deposition of Quaternary Layer E, i.e. it is also a Quaternary feature.

*Layer B.* A white, greenish-white or yellowish quartz sand, locally subdivided by a thin, impersistent layer of small, highly irregular nodules of quartz-rich black 'phosphate'. Immediately beneath the basal phosphatic rock of Layer A, the white sands of Layer B are highly ferruginous and mottled orange or orange-brown. Beneath the median black 'phosphate' layer the sands (i.e. top horizon seen at Locality 2) are more yellow in colour and contain small

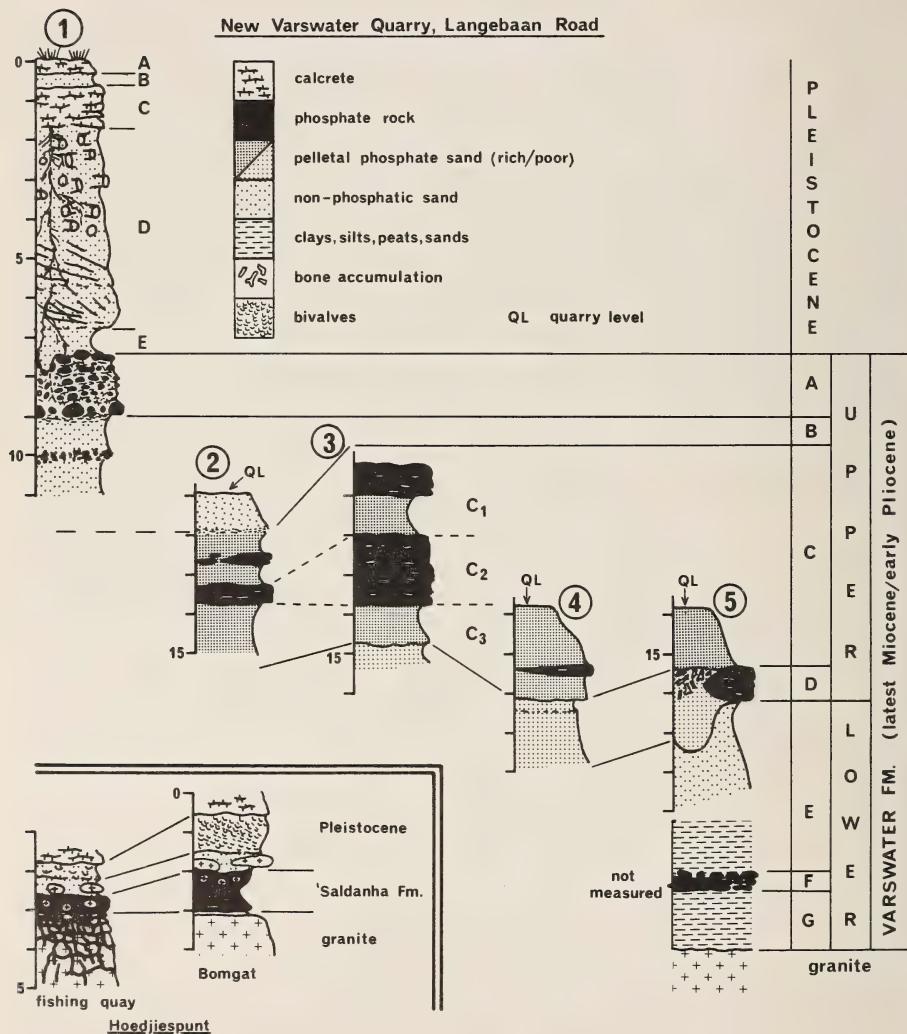


Fig. 3. Measured sections in the New Varswater Quarry, Langebaan Road. Location of numbered exposures is shown on Figure 2. Insert shows exposures in the Hoedjiespunt area of Saldanha Bay—note the occurrence of phosphate-rich veins in the upper part of the granite in the fishing quay exposures. The Bomgat sequence is the stratotype for Tankard's 'Saldanha Formation'. Vertical scales in metres.



quantities of pelletal phosphate. The sands of Layer B are fairly compacted and, especially in the upper half, contain greenish clay-rich clasts. The base of Layer B is iron-stained an orange colour, and locally develops hard nodules.

**Layer C.** A compacted, reddish-brown, fairly well-sorted sand (medium sand size) of pelletal phosphate and quartz, with occasional vertebrate fossils. Several phosphate rock units are developed, some of which can be traced as continuous layers for  $\pm 300$  m, but most are laterally discontinuous and many vary in thickness from a few centimetres to over a metre within distances of 3–4 m. Individual phosphate rocks have a high quartz content and have clearly developed *in situ* by progressive lithification of the pelletal phosphate sand. The rock units are distinctly bedded and lower surfaces of bedding planes are typically wrinkled and nodose. No evidence of penecontemporaneous erosion of upper surfaces of phosphate rock bands was observed.

**Layer D.** Yellowish or white friable sand with a relatively low pelletal phosphate content. This layer locally contains very abundant, sometimes well-preserved vertebrate remains which, from field relationships, appear to be concentrated in two river channels. At one locality (Locality 5) a 0.9 m thick lens of phosphate rock is developed immediately below the junction of Layers C and D and vertebrate remains are concentrated on the upper surface and are banked in a channel against the western edge of this lens (Fig. 4). From field relationships which no longer exist, Hendey (1976) observed that Layer D grades laterally into a complex of sands, clays and carbonaceous silts (D2)

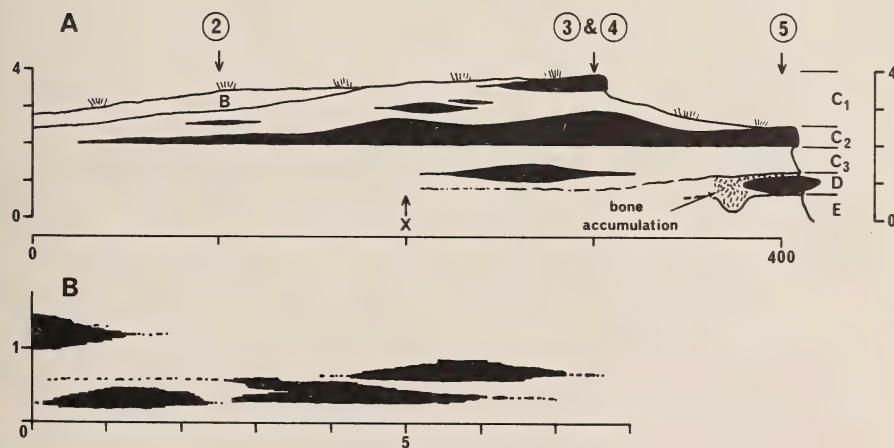


Fig. 4. Sketches of exposures showing distribution of phosphate rock units (shown black) in the upper part of the New Varswater Quarry.

A. A composite section along the north-western wall of the quarry. Numbers are localities in Figure 2. X marks position of the section shown in Figure 4B which is approximately normal to the plane of the sketch.

B. Detail of exposure in unit C<sub>3</sub>. This is located at site 6 in Figure 2.

Scales in metres.



(Fig. 5) which he interpreted as intertidal flat, marsh and flood plain sediments. The upper part of Layer D is typically a deep yellowish colour (iron-stained?) and locally shows an erosional contact with Layer C.

#### *Lower Varswater Formation*

*Layer E.* Only the uppermost part of facies E (Fig. 3) can now be clearly observed. This is a fine-grained soft white quartz sand (E1). Field relationships, previously observable in the quarry, suggested to Hendey (1976) the situation shown schematically in Figure 4 (E1 to E3). The presence of a river channel (E4) is inferred.

*Layer F.* Locally visible in the quarry in dumps from excavations and one undisturbed exposure, and consists of a rounded cobble gravel of brown phosphatic rock with marine invertebrates, sharks' teeth and other vertebrate

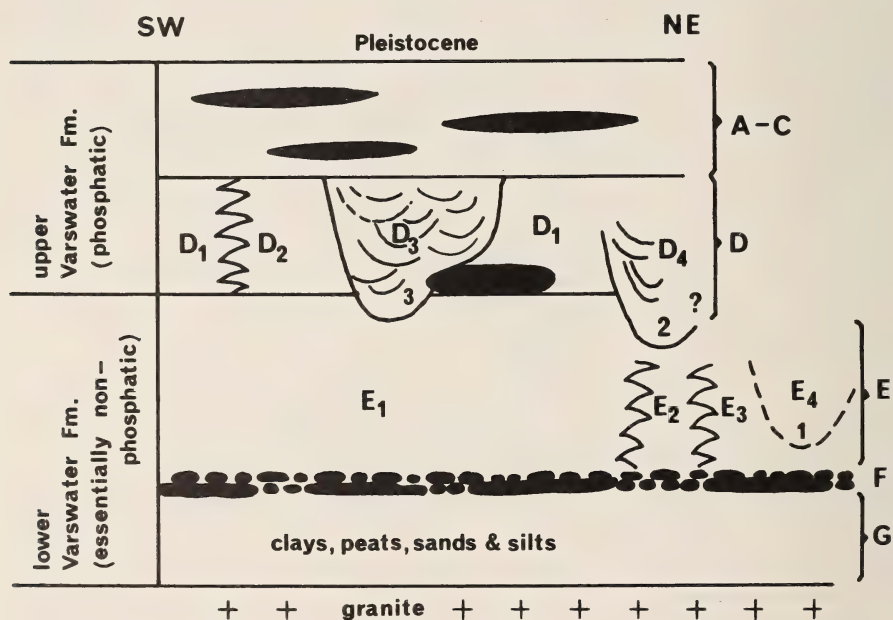


Fig. 5. Schematic relationship of the various facies in the New Varswater Quarry, not to scale. The lower part (units E-G) is taken approximately along a north-west/south-east traverse, and the existence of the river channel  $E_4$  is inferred. Numbers 1, 2, and 3 portray the successive northerly shift in the inferred river channel up the sequence.

A-C—phosphatic sands and phosphate rock.

$D_1$ —phosphatic sands,  $D_2$ —peats and clays,  $D_3$ —river channel sands with accumulation of vertebrate fossils,  $D_4$ —earlier position of river channel.

$E_1$ —quartzose sands,  $E_2$ —peats and clays,  $E_3$ —intertidal clays,  $E_4$ —inferred earliest position of river channel.

F—phosphate rock, locally brecciated and reworked.

G—various clays, peats, sands and silts not exposed in Quarry (from boreholes quoted by Tankard 1975b).

remains. According to Birch (1977: 227) this is the top of a locally brecciated and waterworn phosphatic sandstone unit. Beneath Layer F Tankard (1975*b*, fig. 4.1) has recorded a further *c.* 20 m of sands and clays, none of which is presently visible.

Although many of the field and age relationships are not always clear, the schematic arrangement (Fig. 5) of two river channels overlying the quartz sand of Layer E is supported by the vertebrate fossils, which demonstrate an evolutionary sequence from Layer E to Unit D4 to Unit D3. This relationship can be accounted for by postulating a shift of the river course northwards with time, i.e. D3 is younger than D4, and both are younger than E.

### DISCUSSION

The measured sections described here extend the stratotype section of the upper part of Varswater Formation of Hendey (1974) upwards to include a thick sequence of phosphate sands and rock. A composite sequence for the Varswater Formation based on the authors' sections, previous field observations (Q.B.H.) and borehole data (Tankard 1975*b*) is shown in Figure 6 and Table 1. The essential features are: an upper sequence of phosphate-rich sands and phosphate rock and their lateral equivalents (clays, sands and carbonaceous sediments), and a lower sequence of essentially non-phosphatic sediments (clays, sands and carbonaceous sediments) which is subdivided by an eroded and brecciated phosphate rock.

It is obvious that the phosphate rock layers in the upper part of the succession have formed by *in situ* lithification of the pelletal phosphate sands and that the only proven allochthonous phosphate sediment in this sequence is the Gravel Member. We see no evidence to support the claim that the pelletal phosphate is allochthonous, although the penecontemporaneous lithification of the rock layers (as indicated by the bone banks against the lee of a phosphate rock lens; Fig. 3, Locality 5) means that hard phosphate would have been available for erosion and reworking. From field observations, and the age of the vertebrate faunas, it is clear, therefore, that the phosphate rock units in the Varswater Formation as seen in the New Varswater Quarry were not formed contemporaneously, i.e. the formation of the phosphate rocks in Layer C post-dates the vertebrates in the Layer C, whereas the phosphate rock in Layer D pre-dates the vertebrate remains in the abutting river channel, and Layer F was formed before Layer E was deposited.

Our observations necessitate some modification of Tankard's (1974, 1975*a*) subdivision of the Neogene sediments of the Saldanha-Langebaan area into two formations. In the first place, it is not possible to correlate the stratotype of the Saldanha Formation with any horizon in the sequence in the New Varswater Quarry, and a Miocene age for the phosphatic rocks in the Hoedjiespunt and 'Sea Harvest' factory exposures has not been demonstrated. In addition, palynological determinations in the peat samples in lithological units E<sub>2</sub> and G suggest to Coetzee (1978 and pers. comm.) an age not older than Early Miocene

TABLE 1  
Stratigraphic sequence of present paper compared with those of Hendey (1978a) and Tankard (1974, 1975a).

This paper	Hendey (1978 <i>a</i> )		Tankard (1974, 1975 <i>a</i> )			
Quaternary	Quaternary	Quaternary	Quaternary	Quaternary		
LATEST MIOCENE / EARLY PIOCENE	Upper Varswater Fm. (phosphatic)	A	Pelletal Phosphorite Member (3a N)  Time interval Pelletal Phosphorite Member (3a S)  Time interval	Pelletal Phosphorite Member	VARSWATER FORMATION	
		B				
		C				
		D				
	Lower Varswater Fm. (essentially non-phosphatic)	E	Quartzose Sand Member  Time interval Gravel Member	Fluvial Sand Member  Beach Gravel Member	VARSWATER FORMATION	
		F				
		G				
Granite	Sal. Fm. = Saldanha Formation			Basal Bed	Sal. Fm.	MIO- CENE
				Silty clays etc		?

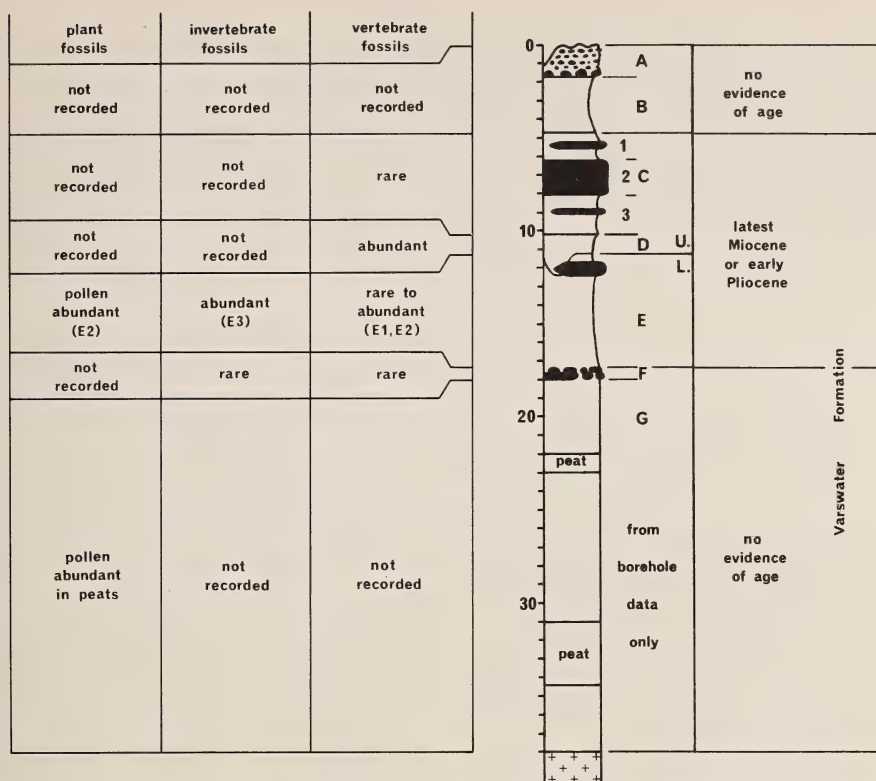


Fig. 6. Composite geological column for the New Varswater Quarry succession, and a summary of the vertebrate fossil occurrences.

for the Lower Varswater Formation, which is consistent with a late Miocene/early Pliocene age for the Upper Varswater Formation vertebrate faunas (Hendey 1978*b*). It may be noted that to the west of the New Varswater Quarry granite basement is overlain by a sequence of clays and sands from which phosphatic rock layers are absent below the main ore body (Visser & Schoch 1973, fig. 6). Secondly, it is apparent from Tankard's (1975*a*) publication that the Saldanha Formation has been erected as a convenience to accommodate all phosphate rock-bearing horizons in the western Cape (for instance, all the offshore phosphatic rocks are placed in the Saldanha Formation because they are phosphatic rocks; 1975*a*: 262). Such a scheme is clearly no longer viable now that it has been shown that thick phosphate rock units occur in the upper part of the Varswater Formation. This does not mean that Miocene phosphatic rocks do not occur offshore, as Siesser (1978) has demonstrated that they do, but it does mean that the relationship between the onshore Miocene (Saldanha Formation) and latest Miocene/early Pliocene (Varswater Formation) sediments as suggested by Tankard (1974, 1975*a*) cannot yet be proven.



## ACKNOWLEDGEMENTS

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## REFERENCES

- BIRCH, G. F. 1977. Phosphorites from the Saldanha Bay region. *Trans. R. Soc. S. Afr.* **42** (3/4): 223–240.
- COETZEE, J. A. 1978. Climatic and biological changes in south-western Africa during the late Cainozoic. *Palaeoecology of Africa* **10**.
- DU TOIT, A. L. 1917. Report on the phosphates of Saldanha Bay. *Mem. geol. Surv. S. Afr.* **10**: 1–38.
- HENDEY, Q. B. 1974. The late Cenozoic Carnivora of the south-western Cape Province. *Ann. S. Afr. Mus.* **63**: 1–369.
- HENDEY, Q. B. 1976. The Pliocene fossil occurrences in 'E' Quarry, Langebaanweg, South Africa. *Ann. S. Afr. Mus.* **69**: 215–247.
- HENDEY, Q. B. 1978a. The age of the fossils from Baard's Quarry, Langebaanweg, South Africa. *Ann. S. Afr. Mus.* **75**: 1–24.
- HENDEY, Q. B. 1978b. Late Tertiary Hyaenidae from Langebaanweg, South Africa, and their relevance to the phylogeny of the family. *Ann. S. Afr. Mus.* **76**: 265–297.
- SIESSER, W. G. 1978. Age of phosphorites on the South African continental margin. *Mar. Geol.* **26**: M17–M28.
- TANKARD, A. J. T. 1974. Varswater Formation of the Langebaanweg–Saldanha Bay area, Cape Province. *Trans. geol. Soc. S. Afr.* **77**: 265–283.
- TANKARD, A. J. T. 1975a. The Marine Neogene Saldanha Formation. *Trans. geol. Soc. S. Afr.* **78**: 257–264.
- TANKARD, A. J. T. 1975b. *The Late Cenozoic History and Palaeoenvironments of the coastal margin of the south-western Cape Province, South Africa*. Unpublished Ph.D. thesis, Rhodes University.
- VISSER, H. N. & SCHOCH, A. E. 1973. The Geology and Mineral Resources of the Saldanha Bay area. *Mem. geol. Surv. S. Afr.* **63**: 1–150.





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*Nuculana (Lembulus) bicuspidata* (Gould, 1845)

Figs 14–15A

*Nucula (Leda) bicuspidata* Gould, 1845: 37.

*Leda plicifera* A. Adams, 1856: 50.

*Laeda bicuspidata* Hanley, 1859: 118, pl. 228 (fig. 73). Sowerby, 1871: pl. 2 (fig. 8a–b).

*Nucula largillierii* Philippi, 1861: 87.

*Leda bicuspidata*: Nicklès, 1950: 163, fig. 301; 1955: 110, Barnard, 1964: 234, figs 8–9.

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R. V. DINGLE  
A. R. LORD  
&  
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NEW SECTIONS IN THE VARSWATER  
FORMATION (NEOGENE) OF LANGEBAAN ROAD,  
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- FISCHER, P.-H. 1948. Données sur la résistance et de la vitalité des mollusques. *J. Conch.*, Paris 88: 100-140.
- FISCHER, P.-H., DUVAL, M. & RAFFY, A. 1933. Etudes sur les échanges respiratoires des littorines. *Archs Zool. exp. gén.* 74: 627-634.
- KOHN, A. J. 1960a. Ecological notes on *Conus* (Mollusca: Gastropoda) in the Trincomalee region of Ceylon. *Ann. Mag. nat. Hist.* (13) 2: 309-320.
- KOHN, A. J. 1960b. Spawning behaviour, egg masses and larval development in *Conus* from the Indian Ocean. *Bull. Bingham oceanogr. Coll.* 17 (4): 1-51.
- THIELE, J. 1910. Mollusca: B. Polyplacophora, Gastropoda marina, Bivalvia. In: SCHULTZE, L. *Zoologische und anthropologische Ergebnisse einer Forschungsreise im westlichen und zentralen Süd-Afrika* 4: 269-270. Jena: Fischer. *Denkschr. med.-naturw. Ges. Jena* 16: 269-270.

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A NEW SPECIES OF DEEP-WATER PALINURID  
LOBSTER (CRUSTACEA, DECAPODA, PALINURIDAE)  
FROM THE EAST COAST OF SOUTHERN AFRICA

By

P. F. BERRY

Cape Town

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By

P. F. BERRY

*Oceanographic Research Institute, Durban*

(With 3 figures and 1 table)

[MS. accepted 20 March 1979]

## ABSTRACT

*Palinustus unicornutus* sp. nov. is described. Of the three previously known species it is morphologically most similar to *Palinustus truncatus* A. Milne Edwards (1880) from the Lesser Antilles in that it possesses a distinct median spine or rostrum on the anterior margin of the carapace instead of the submedian arrangements of the other species. *Palinustus mossambicus* Barnard (1926) was originally recorded from only slightly further north on the east coast of southern African (Mozambique), but there appears to be an error in the locality cited.

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## INTRODUCTION

The genus *Palinustus* comprises the following three species: *Palinustus truncatus* A. Milne-Edwards (1880) from Carriacou, Lesser Antilles, *Palinustus mossambicus* Barnard (1926) from Mozambique, south-western India and the Sulu Sea and *Palinustus waguensis* Kubo (1963) from Japan. Recently two adult female specimens were obtained from deep water off the east coast of southern Africa and named *Palinustus unicornutus* sp. nov. This alludes to the distinctive median spine or rostrum on the anterior margin of the carapace.

## SYSTEMATIC SECTION

*Palinustus unicornutus* sp. nov.  
(Figs 1–2)

### *Material available*

Holotype: SAM-A15880, in the South African Museum, Cape Town. Ovigerous ♀; c.l. 48 mm, t.l. 142 mm. Captured in a lobster pot, September 1976, due east of Boteleur Point, Natal (approximately 26°57'S 32°58'E). Depth 390 m.

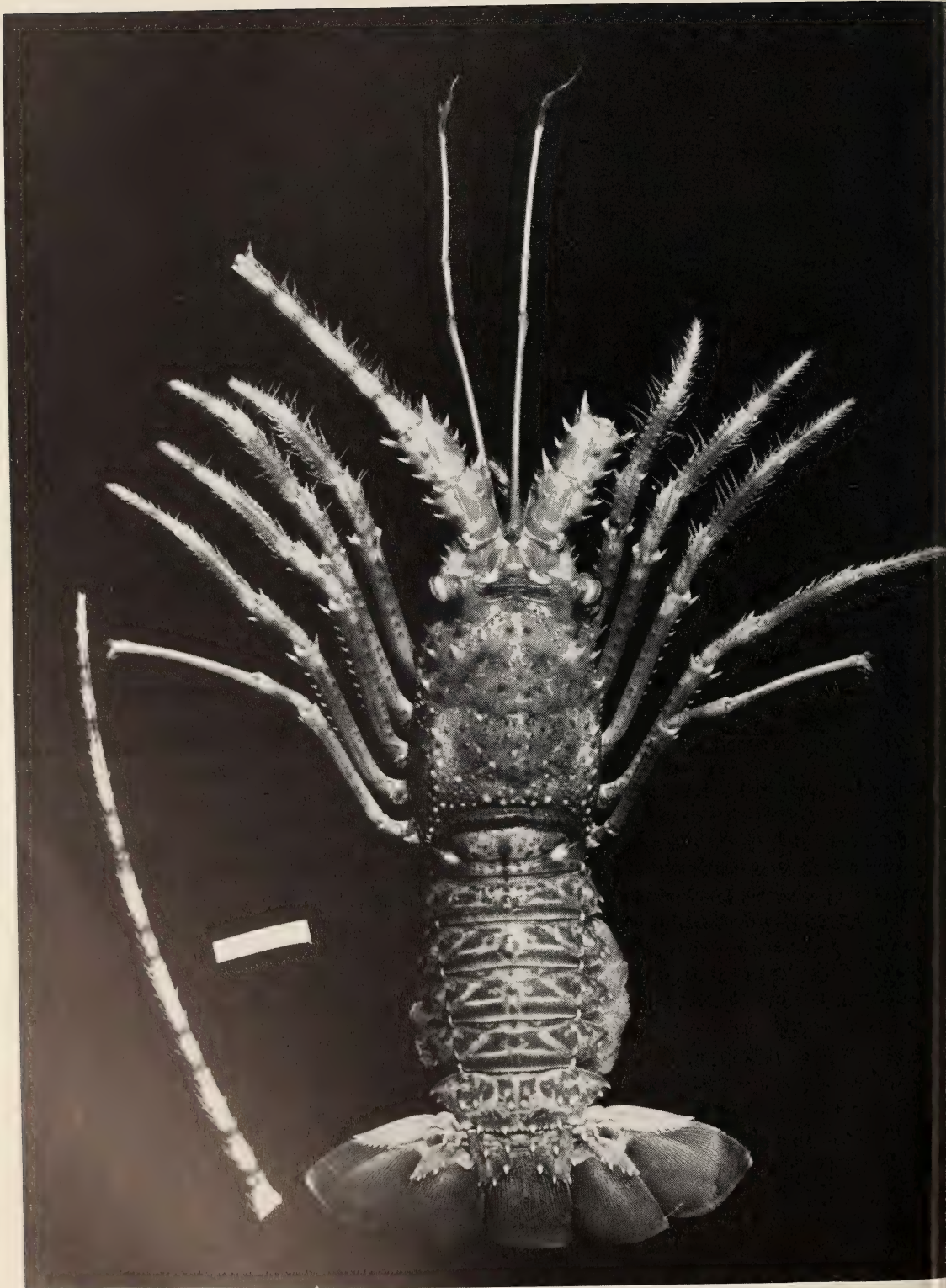


Fig. 1. *Palinustus unicornus* sp. nov. Dorsal view of holotype. Scale = 20 mm.



Paratype: SAM-A15881, in the South African Museum, Cape Town. 1 ♀; c.l. 44 mm, t.l. 134 mm. Captured in a lobster pot, January 1977 off Park Rynie, Natal (approximately 30°19'S 30°56'E). Depth 305 m.

*Other specimens examined*

*Palinustus truncatus*; holotype from Cariacou; Museum of Comparative Zoology, Harvard University. *Palinustus mossambicus*; holotype from Mozambique; South African Museum (SAM-A10684). *Palinustus* sp. incomplete specimen (carapace only) from the Sulu Sea; Western Australian Museum (WAM 1-77).

*Description of holotype*

The supra-orbital processes are truncate distally with irregularly crenulated margins. The inner margins each bear a single minute spine. Arising from the outer margin is a single, large, forward-directed spine. Behind each process is a row of four spines which extends posteriorly to the cervical groove. The frontal margin of the carapace is distinctly convex and smooth except for a single strong median spine or rostrum. The dorsal precervical carapace bears numerous irregularly scattered spinules and four submedian pairs of larger spines increasing in size and diverging posteriorly. Laterally in the precervical region there is a series of three strong spines round the margin of the orbit. The uppermost of these forms the first in a row of three prominent spines which extends posteriorly along the lateral surface of the carapace. The cervical groove is only distinct laterally. The postcervical dorsal carapace bears numerous scattered spinules and a fine covering of setae. There is a converging series of larger submedian spines which tend to be paired anteriorly and to become smaller and more irregularly arranged posteriorly. The spines on the dorsolateral margins of the postcervical carapace are tuberculate.

The eyes are large with constricted peduncles and reniform corneas.

The first abdominal segment has a rounded lateral process on each side which overlaps the posterior margin of the carapace. There is an uninterrupted transverse groove and an indication of a median carina on the posterior margin. Segments 2-5 have an uninterrupted anterior transverse groove and a posterior groove interrupted medially by a flattened, median carina. The posterior margins of segments 4 and 5 show slight crenulations. The pleura of segments 3-6 each bear two strong spurs, the anterior one being larger and slightly hooked. The sixth segment has a median elevated area with an asymmetrical pair of small posteriorly-directed submedian spines. Towards the anterolateral margins of the segment are elevations with two groups of three small posteriorly-directed spines. The posterior margin of the sixth segment bears numerous minute, irregular spines and four large ones.

The telson is elongate, rectangular and about twice as long as wide. The calcified portion bears two lateral spines and three posteromedial spines, one of which is distinctly smaller than the others. Anteriorly there is a transverse row of four strong posteriorly-directed spines.





Fig. 2. *Palinustus unicornutus* sp. nov. Lateral view of holotype. Scale = 20 mm.

The antennular plate is smooth with well-developed lateral ridges on which the stridulating organs slide. The antennules are very long and slender, the basal segment being approximately equal to the carapace length, the second  $0,25 \times c.l.$  and the third  $0,5 \times c.l.$  The flagella are short. The antennal peduncles bear numerous strong, forward-directed spines. The flagella are incomplete but are stout and probably were not longer than about  $3 \times$  the carapace length. They are armed with numerous short spines and are strongly setose.

Pereiopods 1–4 and maxilliped 3 all have longitudinal rows of spines and conspicuous, long, stiff setae, particularly distally. The fifth pereiopod is more slender than the others, bears few spines or setae and is chelate.

The anterior three thoracic sterna each bear a pair of submedian spines; the fourth bears a single median spine and the fifth lacks spines. The posterior margin of the fifth segment bears six posteriorly-directed spinules.

The first abdominal segment bears a pair of slender, uniramous pleopods and a pair of minute submedian tubercles. In segments 2–5 the pleopods are biramous; on segment 2 both exopods and endopods are expanded, but the endopods are slightly smaller. In segments 3–5 only the exopods are expanded, the endopods are narrow, setose and modified as egg-carrying appendices. The ventral margins of segments 2–5 are without spines while segment 6 has one low median tubercle, one pair of low submedian tubercles and several other indistinct tubercles.

The eggs are numerous and small ( $0,55$  mm diameter) similar to the genus *Panulirus*.

The overall colour of the carapace is pale pinkish-orange with some spines dark-red. The colour of the abdomen is basically dark-orange on the elevated areas and white in the grooves. The calcified portion of the telson and uropods is pinkish-orange with the spines white. The uncalcified portions are pale pinkish-orange. The legs and antennae have alternating bands of orange and white. The antennules are uniformly pale orange. The yolk of the egg is yellow.

#### *Description of paratype*

The frontal margin of the carapace is similar to that of the holotype except that the single, minute spinule on the inner margins of each supra-orbital process is absent. The first pair of submedian postcervical spines is set wider apart than the following pair, whereas in the holotype they are equidistant. In all other respects the paratype closely resembles the holotype.

### DISCUSSION

All three species of *Palinustus* described so far are very similar and have been separated largely on the basis of differences in spination on the anterior margin of the carapace and on the epistome (see Table 1 and Fig. 3). *P. unicornutus* is closest to *P. truncatus* in possessing an enlarged median spine on the anterior margin of the carapace and in the similar number and arrange-

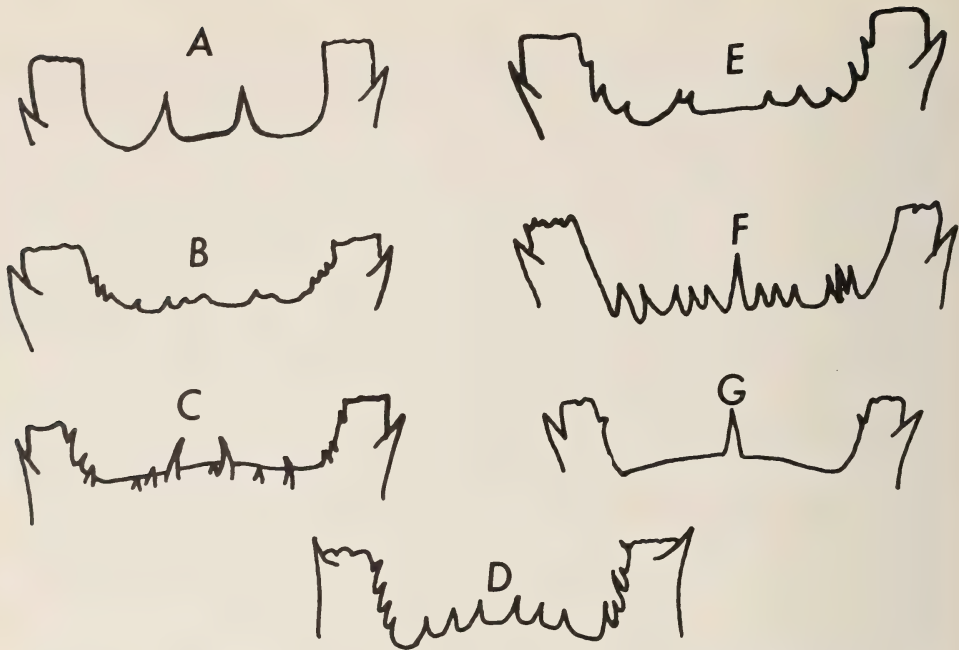


Fig. 3. Sketches of the frontal margins of the carapace of: A. *Palinurus mossambicus* from Mozambique. B. *P. mossambicus* from the Sulu Sea. C. Unidentified Western Australian Museum specimen from the Sulu Sea. D. *P. mossambicus* from south-western India (after George & George 1965). E. *P. waguensis* (after Kubo 1963). F. *P. truncatus* (after Gruvel 1911). G. *P. unicornutus*.

ments of spines or tubercles on the anteromedian edge of the epistome. However, the distinctly convex, smooth anterior margin of the carapace of *P. unicornutus* is in marked contrast to the straight, irregularly spined margin of *P. truncatus*.

Barnard's single juvenile of *P. mossambicus* has a simple arrangement of two submedian spines on a smooth anterior margin of the carapace differing notably from the irregular arrangement of four to five spines present in the specimens assigned to *P. mossambicus* from the Sulu Sea by Holthuis (1946), and the six regularly arranged spines in the specimen assigned to this species from south-western India (George & George 1965). It must be pointed out that the exact locality where Barnard's specimen originated is not known as the position he gives, 25°S 33°10'E (Barnard 1926), is incorrect, being on land.

The present specimens of *P. unicornutus* were taken off the Natal coast during a brief but intensive period of deep-water experimental trap fishing by commercial vessels on rocky substrate.

The specimen in the Western Australian Museum collection which is incomplete, consisting only of the anterior portion of the carapace, was obtained from the Sulu Sea. However, it differs from Holthuis's specimens from the Sulu Sea in having a more distinct pair of enlarged submedian spines on the slightly convex anterior margin of the carapace.



TABLE 1

Differences in spination of the anterior margin of the carapace and of the epistome in *Palinustus*.

	Anterior margin of carapace	Epistome
<i>P. truncatus</i> holotype (Cariacou)	Straight; numerous irregular submedian spines; 1 enlarged median spine.	5 tubercles on anteromedian edge; large spine on anterolateral corners.
Barnard's <i>P. mossambicus</i> (Mozambique)	Straight: smooth except for 1 pair of large submedian spines.	Numerous minute spinules on anteromedian edge, small spine on anterolateral corners.
Holthuis's <i>P. mossambicus</i> (Sulu Sea)	Straight; 4-5 submedian spines of different sizes.	As in Barnard's specimen.
Western Australian Museum specimen (Sulu Sea)	Slightly convex; 1 large submedian pair of spines; 4 other small irregularly arranged submedian spines.	Unknown (specimen damaged).
George & George's <i>P. mossambicus</i> (South-western India)	Convex; 6 submedian spines of approximately equal size.	As in Barnard's specimen.
<i>P. waguensis</i> (Kubo 1963) (Japan)	Straight; bifurcate spine on right side; 2 spines on left side; no median spine.	3 tubercles on anteromedian edge; no spines on anterolateral corners.
<i>P. unicornutus</i> sp. nov. (Natal)	Distinctly convex; smooth; 1 enlarged median spine.	5 (holotype) to 7 (paratype) spines on anteromedian edge; small spines on anterolateral corners.

## ACKNOWLEDGEMENTS

I wish to thank Dr R. W. George for his criticism of the manuscript.

The holotype of *Palinustus truncatus* was lent by the Museum of Comparative Zoology, Harvard University, the holotype of *P. mossambicus* by the South African Museum, Cape Town, and the unidentified specimen from the Sulu Sea by the Western Australian Museum.

## REFERENCES

- BARNARD, K. H. 1926. Report on a collection of Crustacea from Portuguese East Africa. *Trans. R. Soc. S. Afr.* **13**: 126-127.
- GEORGE, M. J. & GEORGE, K. C. 1965. *Palinustus mossambicus* Barnard (Palinuridae: Decapoda), a rare spiny lobster from Indian waters. *J. mar. biol. Ass. India* **7**: 463-465.
- GRUVEL, A. 1911. Contribution à l'étude générale systématique et économique des Palinuridae. *Annls Inst. océanogr. Monaco* **3**(4): 5-56.
- HOLTHUIS, L. B. 1946. Biological results of the Snellius Expedition XIV: The Stenopodidae, Nephropsidae, Scyllaridae and Palinuridae. *Temminckia* **7**: 1-178.



- KUBO, I. 1963. Systematic studies of the Japanese macrurous decapod crustacea. *J. Tokyo Univ. Fish.* **49**: 63-68.
- MILNE-EDWARDS, A. 1880. Reports on the results of dredging, under the supervision of Alexander Agassiz, in the Gulf of Mexico, and in the Caribbean Sea, 1877, 78, 79 by the United States coast survey steamer BLAKE, Lieut-Commander C. D. Sigsbee, U.S.N. and Commander J. R. Bartlett, U.S.N. commanding: Études préliminaires sur les Crustacés. *Bull. Mus. comp. Zool. Harv.* **8**: 66.





6. SYSTEMATIC papers must conform to the *International code of zoological nomenclature* (particularly Articles 22 and 51).

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*Nuculana (Lembulus) bicuspidata* (Gould, 1845)

Figs 14–15A

*Nucula (Leda) bicuspidata* Gould, 1845: 37.

*Leda plicifera* A. Adams, 1856: 50.

*Laeda bicuspidata* Hanley, 1859: 118, pl. 228 (fig. 73). Sowerby, 1871: pl. 2 (fig. 8a–b).

*Nucula largillierii* Philippi, 1861: 87.

*Leda bicuspidata*: Nickles, 1950: 163, fig. 301; 1955: 110. Barnard, 1964: 234, figs 8–9.

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#### Holotype

SAM-A13535 in the South African Museum, Cape Town. Adult female from mid-tide region, King's Beach Port Elizabeth (33°51'S 25°39'E), collected by A. Smith, 15 January 1973.

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FROM THE EAST COAST OF SOUTHERN AFRICA

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- BULLOUGH, W. S. 1960. *Practical invertebrate anatomy*. 2nd ed. London: Macmillan.
- FISCHER, P.-H. 1948. Données sur la résistance et de la vitalité des mollusques. *J. Conch.*, Paris 88: 100-140.
- FISCHER, P.-H., DUVAL, M. & RAFFY, A. 1933. Études sur les échanges respiratoires des littorines. *Archs Zool. exp. gén.* 74: 627-634.
- KOHN, A. J. 1960a. Ecological notes on *Conus* (Mollusca: Gastropoda) in the Trincomalee region of Ceylon. *Ann. Mag. nat. Hist.* (13) 2: 309-320.
- KOHN, A. J. 1960b. Spawning behaviour, egg masses and larval development in *Conus* from the Indian Ocean. *Bull. Bingham oceanogr. Coll.* 17 (4): 1-51.
- THIELE, J. 1910. Mollusca: B. Polyplacophora, Gastropoda marina, Bivalvia. In: SCHULTZE, L. *Zoologische und anthropologische Ergebnisse einer Forschungsreise im westlichen und zentralen Süd-Afrika* 4: 269-270. Jena: Fischer. *Denkschr. med.-naturw. Ges. Jena* 16: 269-270.

(continued inside back cover)







Fig. 1. Die Kelders (DK 1), facing south section A2-A8, showing the late Holocene layers overlying sterile sands.

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CAPE PROVINCE, SOUTH AFRICA  
THE HOLOCENE DEPOSITS

By

FRANZ R. SCHWEITZER

Cape Town      Kaapstad

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# EXCAVATIONS AT DIE KELDERS, CAPE PROVINCE, SOUTH AFRICA

## THE HOLOCENE DEPOSITS

By

FRANZ R. SCHWEITZER  
*South African Museum, Cape Town*

(With 43 figures, 28 tables and 3 appendices)

[MS. accepted 28 March 1979]

### ABSTRACT

The excavations at Die Kelders Cave on the Walker Bay coast represent the first phase in an investigation of the ecology of the indigenous populations of the southern Cape.

The excavations revealed a late Holocene (Later Stone Age) occupation sequence separated by sterile sands from Upper Pleistocene (Middle Stone Age) deposits. This report deals only with the Holocene sequence, which comprises a basal occupation horizon overlain by shell midden deposits. The deposits, dated to the first to fifth centuries A.D., have yielded the earliest firmly dated evidence for domestic sheep and pottery in South Africa.

Analysis of the excavated material indicates winter occupation with heavy reliance on marine resources. This pattern appears to have been modified during the period in which the cave was occupied, changes in the faunal remains indicating an extended stay and a decreased reliance on small wild bovids. Differences in the stone artefacts of the initial occupation horizon and the overlying shell midden layers are discussed and it is suggested that the informal nature of the lithic component, together with the wide range of formal bone tools, reflects differing needs arising from a stay at the coast compared with those arising from occupation of inland sites.

It is concluded that the economic changes were related to the increasing availability of domestic stock, but that at this period this new food source did not significantly change the subsistence economy and technology of the late Holocene populations of the Cape Biotic Zone.

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## INTRODUCTION

The Gansbaai coast, which is the geographic focus of this research, is identified as the rocky eastern shore of Walker Bay, a wide, deep embayment in the coastline just west of Cape Agulhas, the southernmost point of the African continent (Fig. 2).

This stretch, indeed, the whole Walker Bay coast and its immediate hinterland, is an area where arable land is limited, soils are poor and population is relatively low. Proximity to Cape Town, however, has led to its increasing importance as a recreation area with a large influx of vacationers during the summer season and at week-ends, and to a noticeable increase in land division for residential plots. As a result the archaeological sites located here have

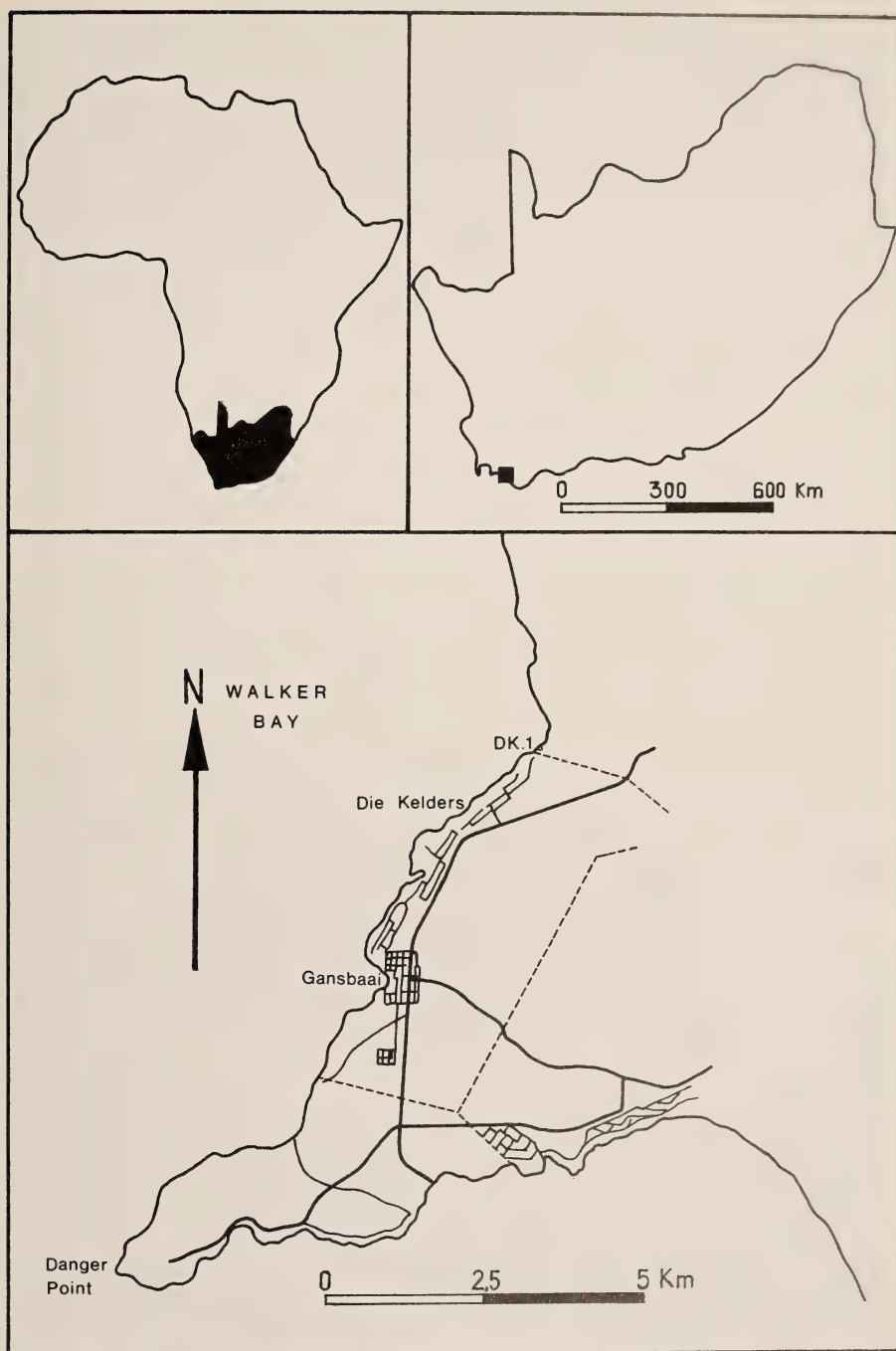


Fig. 2. Map showing relative position of DK 1 site.

become endangered to a greater degree than previously. It is against this background of modern development that the research programme of the South African Museum in the south-western Cape in general and the Gansbaai area in particular can be viewed—as basic problem-orientated research anticipating conditions that could make salvage archaeology increasingly important in the future.

The resort village of Die Kelders ( $34^{\circ}32'8''\text{S } 19^{\circ}22'33''\text{E}$ ) has long been known for its caves and subterranean springs (Wilkins *ed.* 1901: 165–166). Some of these caves have been formed by water draining through limestones under cover of aeolianites and dune-sand to the sea. This drainage ensures a plentiful supply of fresh water along this part of the coast. Other caves are wave-cut, and in some both seepage and wave action have played a role in their formation.

A number of caves at Die Kelders contain remains of prehistoric occupation. The most prominent of these is the Klipgat Cave complex which consists principally of two large, high-roofed chambers at the foot of a 12 m cliff. The chambers have been eroded out of the cliff limestones and are separated by a rock-wall containing smaller openings and passages (Fig. 3). Part of this complex, designated Die Kelders 1 (DK 1), was chosen for study as it contained apparently undisturbed Holocene shell-midden deposits, and potentially offered a succession of occupation horizons that could help to establish a chronological and culture-stratigraphic framework for the area. It seemed that by concen-



Fig. 3. Klipgat cave complex viewed from the west, with DK 1 behind the staff bearer on the right.



trating efforts on the detailed analysis of finds from this site a direct contribution could be made to the study of the cave-dwellers and to the prehistory of the Gansbaai coast.

Numbers of archaeological sites in the area are known (Rudner 1968; Avery 1975), but only three cave sites received mention in the archaeological literature prior to the commencement of excavations at DK 1 in 1969. Péringuey (1911: 143-7) described two caves at Hawston, some 30 km north-west of Die Kelders. One cave is reported to have yielded two ostrich egg-shell beads and a 'scraper knife'. The other was said to have contained a quantity of animal and human bones which Péringuey interpreted as the result of alternate occupation by man and beast. The Hawston caves have not been relocated and, judging by the reported removal of slabs from the roof for building purposes (Péringuey 1911: 143), they may no longer be in existence. The reported layout of the cave, which included six or seven fissures radiating from part of an open chamber, suggests that, in part, the cave was a porcupine lair (C. K. Brain pers. comm.). This view is supported by a recent re-examination of faunal material from the site, which is housed in the South African Museum. The examination revealed the presence of a large proportion of carnivore remains and a high percentage of porcupine-gnawed bone (C. K. Brain pers. comm.). It is difficult to evaluate Péringuey's observations in the absence of detailed stratigraphic and content information, but it seems reasonable to accept his conclusion that the site was used both by people and wild animals. It is not possible to detail the context of most of the material, but the finds suggest that horizons of very different time levels in the Holocene and Upper Pleistocene were excavated. Péringuey's faunal list differs markedly from that of DK 1 (see Table 27).

The third site mentioned in the literature is Klipkop Cave in the Hoy Park nature reserve in central Hermanus, some 18 km north-west of Die Kelders. It was first excavated by J. Drury of the South African Museum and further excavations were undertaken by W. H. Pattersen who was in charge of the nature reserve. In 1935 A. J. H. Goodwin, of the University of Cape Town, and K. H. Barnard, of the South African Museum, spent three days excavating one of the remaining sections of the deposit. The history of the investigations was recorded by Goodwin (1930*a*: 211 ff).

Since, in 1969 when this project was started, there was no active programme of intensive research on shell-middens which included systematic excavations, there was both the potential for and the desirability of such studies being undertaken.

Any archaeological excavation programme is liable to be time-consuming and the excavation of DK 1 was spread over seven field seasons lasting from 1969 to 1973. The reason for this was that the total sequence included some 7 m of deposit resting on a fossil boulder beach and ranging in age from early Upper Pleistocene to Holocene. The occupation of DK 1, then, was unexpectedly long and complex and the most recent phase of occupation, which is reported



here, comprised only the upper few metres of the sequence. This was separated from another phase of use of the cave in early Upper Pleistocene times by thick layers of natural sand deposits representing an accumulation over several tens of thousands of years. The earlier phase of occupation will form the basis of a further report.

The excavation of the DK 1 deposit was based on standard procedures of stripping off natural stratigraphic layers. The deposits are complex in detail but reasonable success was achieved and, in the absence of horizontal layering, such an approach was essential.

Shell-middens include materials other than shell but are in the main garbage heaps of inedible residues from food. From the investigation of cave situations such as DK 1, it was obvious that much of the information recovered would relate to subsistence economy and thus the focus given to the research was the ecology of prehistoric peoples of the Gansbaai coast. It is not possible in the design of archaeological research that includes exploratory excavation, as in this case, to anticipate what will be found below ground. The nature of the deposits in DK 1 was such that the excavation exposed not only the upper shell-midden layers but also earlier Upper Pleistocene horizons that intersected the surface where piled up against jutting-out wall rock. This meant that the strategy of the investigation had to be changed to allow the testing of the earlier and deeper deposits down to bed-rock.

At a later stage in the investigation, when it was established that sheep remains were more abundant in a particular area of the deposit and in a specific layer, the excavation was extended to provide better samples of the sheep remains. In this case a more problem-orientated approach could be followed because the finds of domestic animal remains in this context immediately posed the problem of whether the occupants were hunter-gatherers who had obtained sheep by chance, or herders. As a study of the age distribution in the sheep sample appeared to offer the best means of distinguishing between the two possibilities, adequately large samples of sheep bones had to be recovered.

The extended nature of the excavation entailed the preparation and publication of a number of interim and specialized reports. Some of these go beyond the scope of the present study in that they consider the earlier occupation of the site. The first publication (Schweitzer 1970) summarized the first two seasons of fieldwork at Die Kelders. It gave initial descriptions of the stratigraphy of the Upper Pleistocene and Holocene deposits, the archaeological finds and relevant radiocarbon dates. A further short report (Schweitzer 1972) was included in a review dealing with current archaeological research. The results of the later excavations in the Holocene layers, designed to recover an increased sample of sheep bones, were published in a short note (Schweitzer & Scott 1973) that described the occurrence, composition and dating of the sheep remains which at the time were the earliest known finds of positively identified sheep in South Africa. A further and fuller report (Schweitzer 1974) included a detailed analysis of the sheep bones and attempted to answer the problem of whether

the sheep in layer 2 had been kept and eaten by pastoralists or obtained by one or other means by the hunter-gatherers. A complete site report formed the basis of a thesis submitted in 1975 to the University of Stellenbosch towards a M.A. degree (Schweitzer 1975) and the present study is a modified version of that thesis.

Analyses of the sediments from the site were presented in two papers (Tankard & Schweitzer 1974, 1976) which point to human and natural debris having accumulated in the cave over an estimated time range of 100 000 years. These analyses suggest that the 40 000-year period of non-occupation prior to the relatively late arrival at the site of the Holocene inhabitants was due, initially, to the creation of a sump through water seepage and, later, to the sealing off of the cave by a shifting dune similar to those found in the area today.

A methodological problem in connection with a large site such as DK 1 is at what stage to accept that the investigation is complete. Obviously at the present stage reached there is much more work that can and should be done at the site. The excavations have been on a limited scale, the more so in the earlier deposits. Practical considerations enter into excavation strategy and, for example, to excavate the Upper Pleistocene levels larger areas of overlying occupation deposits have to be removed and these cannot simply be stripped off and discarded. In respect of the Holocene midden accumulation described in this report, an area of some 85 m<sup>2</sup> has been excavated. On the one hand this has been adequate to produce a significant sample of artefacts and food residues for study, but on the other hand it is inadequate for studying spatial distribution patterns that can inform on the use of the floor-space of the cave, from which socio-economic inferences may be derived.

Given the results presented in this report, some statement can be made on the economy of the late Holocene peoples at DK 1, and it is proposed to extend these observations at the same level to another site, Byneskranskop, in a slightly different setting but in the same local area. This leaves open the option of extending the Die Kelders excavation at a later stage in the development of our understanding of the prehistory of the region.

The methodological approach adopted in this study developed in the course of the excavation and during the laboratory analysis of the material. The occupation deposits studied relate to people who were hunter-gatherer-fishermen at a stage when herding was being introduced into the area. The valid approach here has seemed to be the study of changes in the behaviour of people increasingly reliant on herding. Despite the impact of pastoralism on their way of life, the late Holocene peoples on the Gansbaai coast retained an economy largely based on the exploitation of the natural resources of the local environment. The viewpoint of this study may be defined as ecological in that it seeks to examine the interaction between these people and their environment. It is relevant not only to study the visible evidence of the way these people exploited their environment but also to consider how the environment's

potentials and limitations may have affected their activities and, finally, how these activities may have affected the environment.

In practice this approach has entailed the identification and quantification of a wide range of residues from the site and this has been possible only through close co-operation with biologists, geologists and palaeontologists. This is reflected in the text by reference to specialist studies and in the appended reports.

## GEOGRAPHICAL AND ENVIRONMENTAL SETTING

### PHYSIOGRAPHY

The physiography of the south-western Cape coastal belt, including Walker Bay, is dominated by mountain ranges of Table Mountain Sandstone (T.M.S.) which run more or less parallel to the coast. In the vicinity of Die Kelders the outliers of these mountains reach a height of some 350 m and are separated from the sea by a low-lying coastal plain which varies in width from about 3 km near Gansbaai to 10 km further north. The coastal plain in the Die Kelders area is mainly underlain by limestones covered in part by calcareous aeolianites and dune-sands. It is in the limestone that the main caves are cut (Figs 3-4).

Many of these caves, including DK 1, have been eroded along the interface between the folded T.M.S. which has been locally planed at 7-8 m above sea-level, and the late Cenozoic Bredasdorp Formation, a marine limestone



Fig. 4. DK 1, left of staff, before excavation.



which lies unconformably on the sandstone. The basal part of the limestone is an angular to sub-angular breccoid horizon, passing upward through horizontally bedded, fine quartzose sands with much comminuted shell and, finally, into massive limestone.

#### GEOLOGY

The youngest sediments in the area are late Pleistocene calcareous aeolianites of last glacial age and superficial modern dune-sands, the latter forming a prominent landmark clearly visible across Walker Bay. The calcareous aeolianites exhibit clear dune bedding dipping predominantly in a northern to north-western direction. Outliers of these sediments lying on local promontories and islands of Palaeozoic quartzite (T.M.S.) attest to their more seaward extension during the lowered sea-levels of the Upper Pleistocene. Northwards along Walker Bay the calcareous aeolianites that extend below beach level are being eroded back by the sea along the length of the bay. These easily eroded sediments show no evidence of having been planed by any sea higher than the present. Cross-bedding within the calcareous aeolianites shows that a dominantly south-easterly wind direction prevailed during their formation.

#### CLIMATE

The south-easterly wind direction is still dominant along the coast in summer and often reaches gale force. In winter the prevailing north-westerly winds usually bring rain. These south-east and north-west components of the wind system are elements of the Mediterranean-type climate of the south-western Cape with warm, dry summers and wet winters. The climate is relatively mild, and the coastal belt, which includes the Gansbaai area, has an average daily maximum temperature of about 24°C in midsummer and 16,5°C in mid-winter (Schulze 1965: 2). This area is also frost-free, and snow is restricted to the higher parts of the more inland mountain ranges, but even there it usually does not lie on the mountain slopes for more than a week or so after a fall. Hail is rare, and thunderstorms occur on average less than five times a year. Because temperatures are generally lower in the wetter mountain areas, they offer a less favourable habitat than the valleys or coast.

The main rainfall period is from May to September, and precipitation is profoundly influenced by the pronounced orographical features of the south-western Cape. This results in a mean annual rainfall of over 3 000 mm in some mountain kloofs, 400–500 mm on open areas such as the Cape Flats, and less than 250 mm in valleys such as that of the Breede River (Schulze 1965: 313).

#### DRAINAGE

There is no major river in the Gansbaai area, but drainage from the mountains gives rise to a few small seasonal rivers and streams as well as perennial fissure-fed springs. The rivers and streams, in their meandering across the coastal plain, form marshes and small, shallow lakes or vleis. Some of these



result from the closing of the river mouths by dune movement during the windy summer months and others are the result of the low gradient of the surrounding flat countryside and the variable precipitation. There are three perennial springs in the vicinity of Die Kelders, produced by water seeping through the limestone and moving along the upper surface of the underlying T.M.S. until they surface near the shore. One of these, some 100 m from the cave site, delivers about 910 000 litres daily throughout the year.

#### VEGETATION

In the south-western Cape the natural vegetation consists of sclerophyllous scrub known as fynbos, which extends from the mountains to the coast. The different local environments, however, with their particular topography, soil and precipitation, influence the character of the vegetation and, following Taylor (1972), the vegetation can be divided into a mountain and a coastal fynbos. The cave is in the area of the coastal fynbos growing on the lime-rich marine sands. Although there have been changes caused by recent land-use patterns resulting in the expansion of the open dunes during historical times and the accelerating spread of exotics, it is probable that the present vegetation is relatively little changed from that which existed during the Holocene occupation of the site. Support for this contention comes from the absence of evidence for marked climatic and sea-level changes in the late Holocene. Taylor (1972: 17) suggests that the fynbos is a natural climax vegetation, unlike Mediterranean-type vegetations found in some other parts of the world, notably the macchia of France and the gorrigue of southern Spain, where the effect of human interference is more pronounced.

The local fynbos includes typical elements and species of the families Restionaceae (Cape reeds), Ericaceae (heaths) and Proteaceae (proteas) as well as a number of grasses which, though limited, make good grazing. In the sheltered troughs between dunes *Sideroxylon inerme*, white milkwood (melk-hout) trees of the temperate coastal forests develop. In addition, there are local forest remnants (Taylor 1961) of the type now restricted to the wetter Knysna area some 400 km further east. The survival of these forest patches in the vicinity of DK 1 is confined to sheltered locations further inland.

Fynbos is a fire-climax vegetation that must be burnt to retain its identity as a plant association. Many component species need fire for their reproduction and survival (Taylor 1972: 16). This requirement also favours exotic pest plants such as hakea and the Australian acacias, *A. cyanophylla* (Port Jackson willow) and *A. cyclops* ('rooikrans'), which are now spreading in the area at an alarming rate. Unless checked, they may thus replace the fynbos and have already done so in some areas.

#### FAUNA

The terrestrial fauna is now considerably depleted, but still includes numbers of small antelopes belonging in the main to the genus *Raphicerus*. Testudinidae (tortoises), Bathyergidae (dune mole-rats) and Hyracoidea

(dassies) are still numerous, and tortoises and dune mole-rats in particular provided much of the cave occupants' diet. Bird life is prolific with more than sixty-five species recorded from this area. These include sea birds, pelicans, birds of prey, freshwater birds and migrants, many of which form seasonal flocks numbering several hundred. It is, however, the marine birds that were important to the cave inhabitants. Modern fishing and trawling have made great inroads into Walker Bay's off-shore fish population, but marine life along the shoreline has been changed to a lesser degree, largely due to the enforcement of protective legislation. The intertidal zone between high and low spring tides was readily accessible to early hunter-gatherer-fishermen and, as the shell-middens testify, important in their subsistence economy. Here, as on other rocky shores of the south-western Cape, the coastal zone can be divided into three sub-zones on the basis of the abundance of certain characteristic animals and seaweeds (Barnard 1954: 9). The shellfish fauna of the uppermost or Littorina zone is submerged only by the high water of spring tides and is generally too small to make worthwhile eating. The Barnacle zone, named after its most common organism, is covered by the normal high tides and includes some edible species. It is, however, in the third or Cochlear zone, only fully exposed at especially low spring tides, that most limpets (*Patella* spp), an important food source, are found. Also of importance is the sub-littoral zone, the upper fringe of which may be visible at very low spring tides (Barnard 1954: 10), where the brown kelp stems are rooted and red bait (*Pyura* spp), abalone ('perlemoen') (*Haliotis* spp), rock-lobsters (*Jasus lalandii*), and 'arikreukel' (*Turbo* spp) are best developed.

Die Kelders falls into one of two overlap regions joining the three principal coastal biological zones of South Africa. This is the 'western overlap' (Stephenson 1944) which stretches from Kommetjie on the Atlantic coast of the Cape Peninsula to Cape Agulhas on the south coast. It links the colder waters of the Benguela current, which has a mean annual temperature of 12°C with a 2-3° variation off Cape Town, to the warmer Agulhas current, which reaches the south coast from the Indian Ocean. This has a mean annual temperature of 19°C with a range of 5-6°C (Schalke 1973: 8). The resultant overlap, though manifested by a progressive west-to-east change of the intertidal marine fauna populations, is not at all uniform. It has, therefore, been subdivided into zones of different water temperature, with Die Kelders and its well-developed kelp fields occupying a colder water subcompartment extending from Cape Hangklip to Danger Point (Stephenson 1944: 339) (see Fig. 5).

These temperature gradients are mentioned to draw attention to the need for exercising caution when comparing marine faunal compositions from Die Kelders with similar assemblages derived from sites situated elsewhere, even relatively short distances away. Not only is there a gradual change in fauna and flora from west to east coasts, but 'it should also be remembered that a species which occurs between tide marks along one stretch of coast may be present below tide marks along another' (Stephenson 1944: 272).

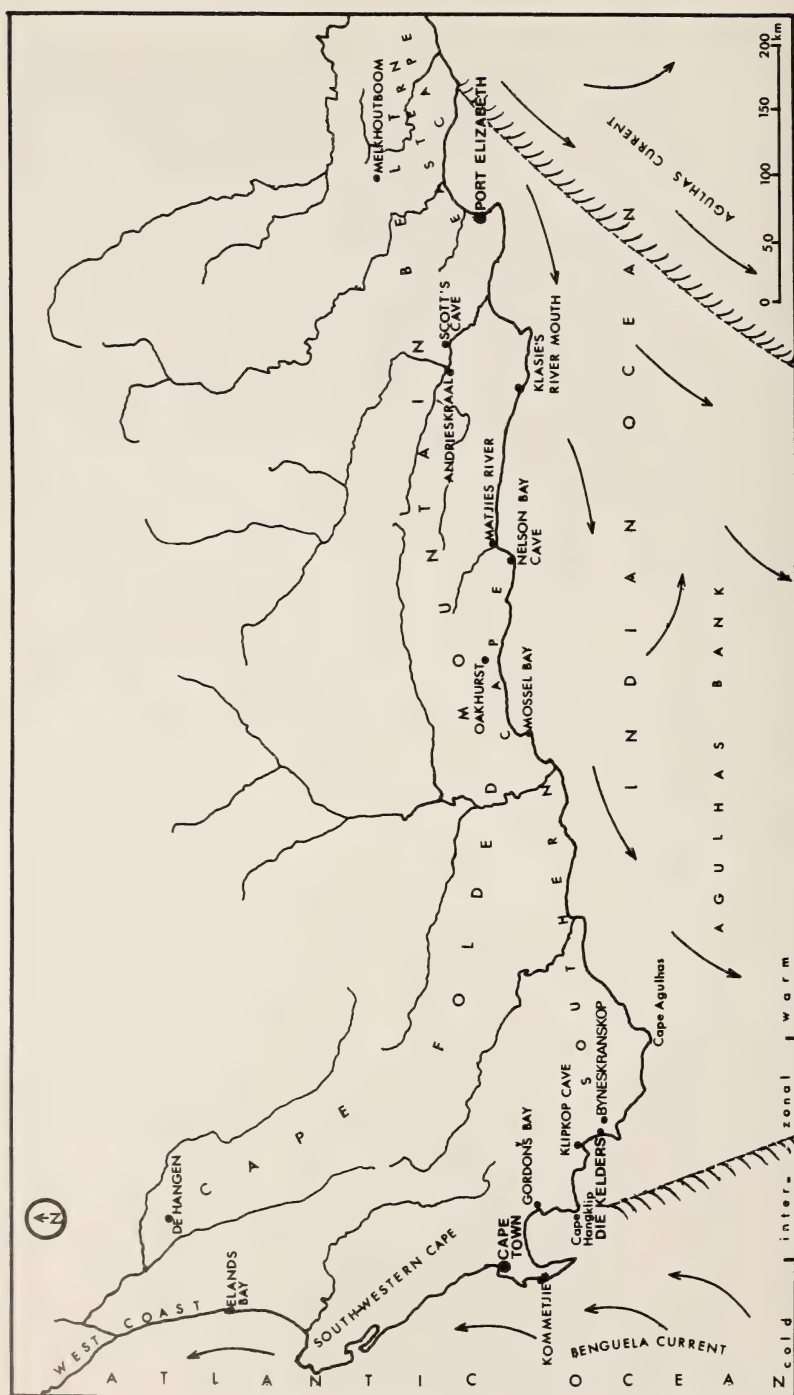


Fig. 5. Map of the southern and south-western Cape showing ocean currents and marine temperature zones (after Kensley 1973: 5) and the location of Die Kelders in relation to other excavated sites mentioned in the text.



## ENVIRONMENT AND HABITAT

The area in which DK 1 is situated may be seen as a series of environmental zones affording a range of differing habitats. These zones may be considered broadly as:

1. *The sea-shore*

The sea-shore may be divided into three micro-environments:

*the rocky T.M.S. coastline*, running south from DK 1 to Danger Point, is the habitat of the principal shellfish species, black and brown mussel (*Choromytilus meridionalis* and *Perna perna*), found in the cave's midden deposits, as well as of the most common fish, 'hottentot' (*Pachymetopon blochii*);

*the limestone cliffs* in which there are numerous caves and three perennial freshwater springs; that both these features were attractive to human beings is evident from the extensive occupation debris in the Klipgat Cave complex;

*the sandy beach* which begins a few hundred metres north of the site and stretches for about 14 km to Hermanus. The tidal surf is the habitat of the white mussel (*Donax serra*), shells of which are also found in the DK 1 deposits.

2. *The dunefields*

The open dunefields today form a spectacular but almost barren environment. There are, however, occasional patches of shrub in sheltered localities, and small antelope are sometimes to be seen. Potsherds and other remnants of late Holocene human activity have been found in the dune troughs (Rudner 1968: 59), which suggest that this environment was considered suitable for some degree of occupation.

3. *The coastal peneplain*

The coastal peneplain, which consists of large areas covered by fynbos, includes a number of vleis. The vegetation undergoes a progressive change, relative to the distance from the sea and shelter from prevailing winds, generally marked by an increase in the height of the vegetation. The area provides a wide range of flora and fauna and would have been attractive to hunter-gatherers, although they seem to have preferred to locate their settlements closer to the shore in the caves and in the shelter of the milkwood trees on the seaward edge of the plain. It should be noted, however, that open station sites in the more dense vegetation would have a much lower visibility.

4. *The mountain*

In the upper reaches of the Franskraal mountains, fynbos becomes increasingly sparse and the area is bare and rocky. There is a large rock-shelter about half-way up the mountain, clearly visible from the peneplain. This shows evidence of past human occupation in the form of marine shells, tortoise remains and flaked pebbles (G. Avery pers. comm.). No detailed survey of the mountain has been undertaken, though it is known that the shallow vlei on



the plateau, as well as those on the coastal plain, supplied local inhabitants with small turtles (*Pelomedusa subrufa*) in recent times (J. Kemp pers. comm.).

#### CONCLUSIONS

The situation of DK 1 shows that many advantages were offered to the hunter-gatherer-fisher and possible herder groups living there by the number of micro-environments within easy reach. In addition to the obvious benefits of shelter and proximity to fresh water and food resources, the cave offered protection at the base of a cliff. Moreover by facing north it provided a maximum of sunshine during the winter months when evidence indicates it was occupied.

### ARCHAEOLOGICAL OBSERVATIONS AT DIE KELDERS

#### INTRODUCTION

The deposits in the DK 1 section of Die Kelders Klipgat Cave complex form a sand-covered mound that is well protected by the overhanging roof. There was little eroded material on the surface, but a surface collection included finds of a broken decorated bone linkshaft, ostrich egg-shell beads and flaked stone artefacts. Archaeological investigations of the deposits then depended on excavation. An area of some 85 m<sup>2</sup> was excavated in the top 2 m of midden accumulation and a reduced area was excavated for some 5,5 m to a basal deposit near the present mean sea-level.

The excavation exposed a deep vertical section through the cave deposits and this has provided the basis for the study of the stratigraphic history of the accumulation that is discussed below. Attention has been given to both the gross stratigraphy of the whole sequence and the micro-stratigraphy of the topmost occupation unit, the late Holocene midden accumulation that is the concern of this report. Samples of charcoal and bone were collected for radio-carbon dating and, while the results of these age determinations are discussed elsewhere in the text, it can be said here that dating of the upper occupation is satisfactory, although bone apatite dates from the Pleistocene occupation levels have given results that are considered anomalous. In other sections the excavation procedures adopted and the artefactual finds are discussed. The products of the excavation in terms of both artefacts, objects made or modified by man, and food refuse are very numerous, and routine sorting, cleaning, cataloguing and housing the finds has been a major task. The artefactual finds have been analysed according to the raw material used, context, form and function. The other class of finds or remains analysed is the food refuse. This is artefactual in the broadest sense, having been introduced by man, but primarily provides information on the economy of the cave occupants. The sampling, identification and interpretation of the food remains has formed a major part of the study. There is clearly considerable potential for detailed analysis of such finds. It is an almost open-ended study that requires reasoned explanation for the inclusion in the deposit of each different kind of remains, be it a bone of a particular

species of bird or an otolith of a species of fish. The interest lies in information on how man adapted to his effective environment and how he influenced it, and ecological studies of the prehistoric Die Kelders inhabitants are continuing.

The excavation of the Die Kelders cave has yielded a human burial, rather poorly preserved, in a side passage (see Appendix 3).

#### STRATIGRAPHY

##### DESCRIPTION OF THE GROSS STRATIGRAPHY OF THE CAVE DEPOSIT

The stratigraphic sequence at DK 1 comprises more than 7 m of deposit. A full description has been given by Tankard & Schweitzer (1974, 1976), and the main depositional units or members are described in outline here.

##### *A basal layer of beach sands*

This overlies a beach cobble-boulder bed, the lowest horizon that was intersected. The beach cobbles are thought to be the initial fill of the cave and to date to a previous high sea-level of last interglacial age.

##### *The Upper Pleistocene deposits*

The marine deposits are overlain by an Upper Pleistocene (Middle Stone Age) member made up of alternating occupation and non-occupation horizons. These horizons formed during a regression but, as marine mammals are included in the occupation horizons, it can be argued that the shore was within easy reach of the cave.

##### *A yellow iron-stained sand member*

This conformably overlies the Upper Pleistocene member. There is no evidence of human occupation in these sands and the faunal remains are restricted to isolated, small rodent bones. It has been reasoned that these sands accumulated during a major regression and, as a result of waterlogging and sealing off by dunes, the cave was effectively uninhabitable. The suggested time range of accumulation of these deposits is from an estimated 45 000 to about 9 000 years ago (Pta-1456, derived from charcoal in the uppermost levels:  $9620 \pm 100$  years B.P.).

##### *A pink, shelly sand layer*

This overlies the yellow sands and indicates a return to a post-Pleistocene higher sea-level and the reopening of the cave. The two sand members are disconformable and easily distinguished in the field (Fig. 1).

##### *The shell midden*

The uppermost member in the sequence marks the final occupation of the cave in the late Holocene. This is a complete unit in itself and comprises a 1–1.5 m shell accumulation interspersed with sand and ash lenses (Figs 1, 6–8). It is capped by a partly cemented, powdery grey sand which serves to protect

## DK1 WEST SECTION AA8-E8

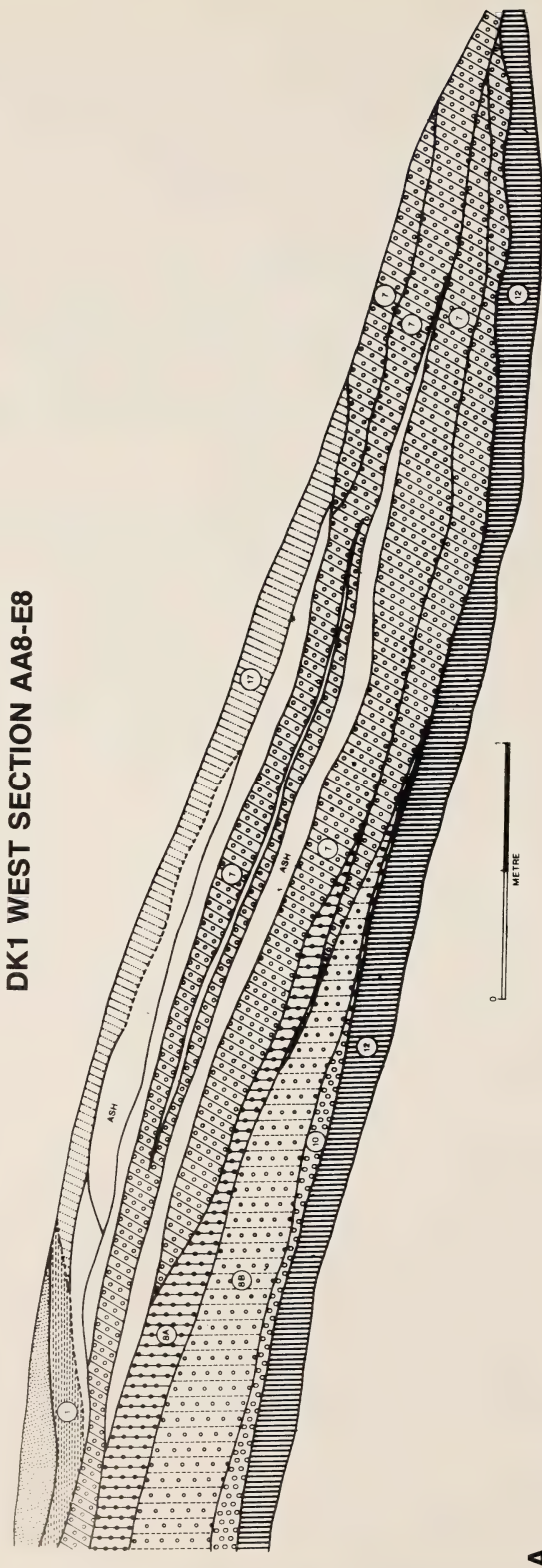


Fig. 6. DK 1, section drawings. A. West section AA8-E8. B. South section AA2-AA8.  
C. East section AA2-G2. D. Sampa's cave, north section A1-A95.



B

DK1 SOUTH SECTION AA2-AA8

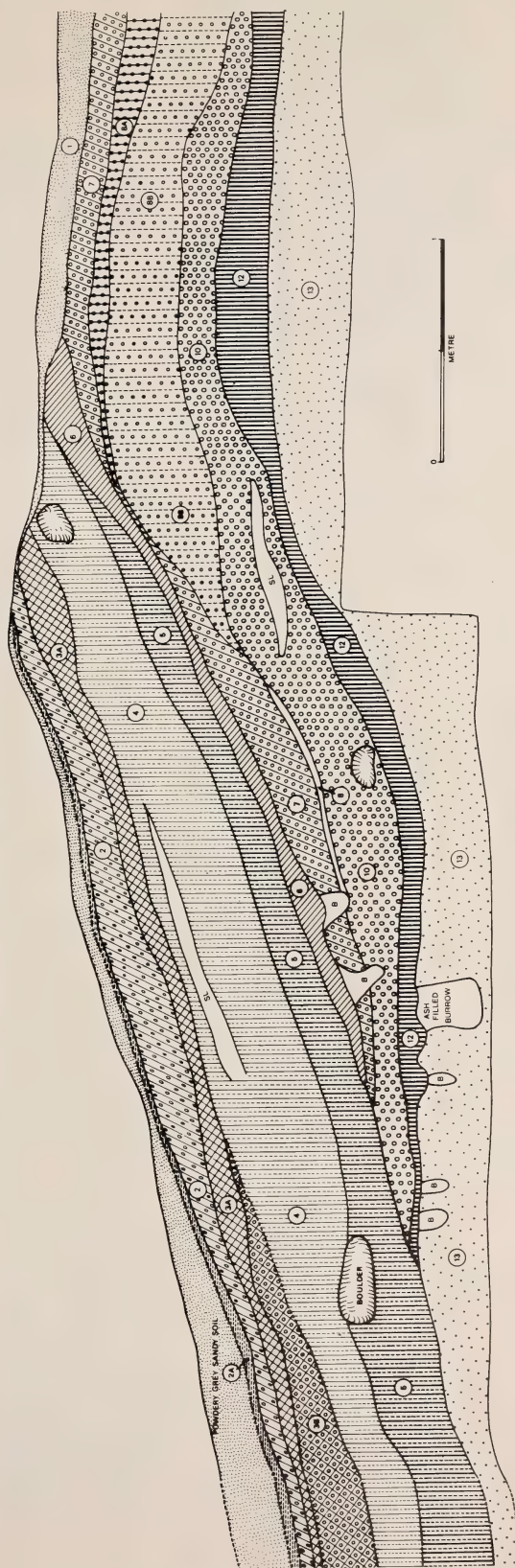
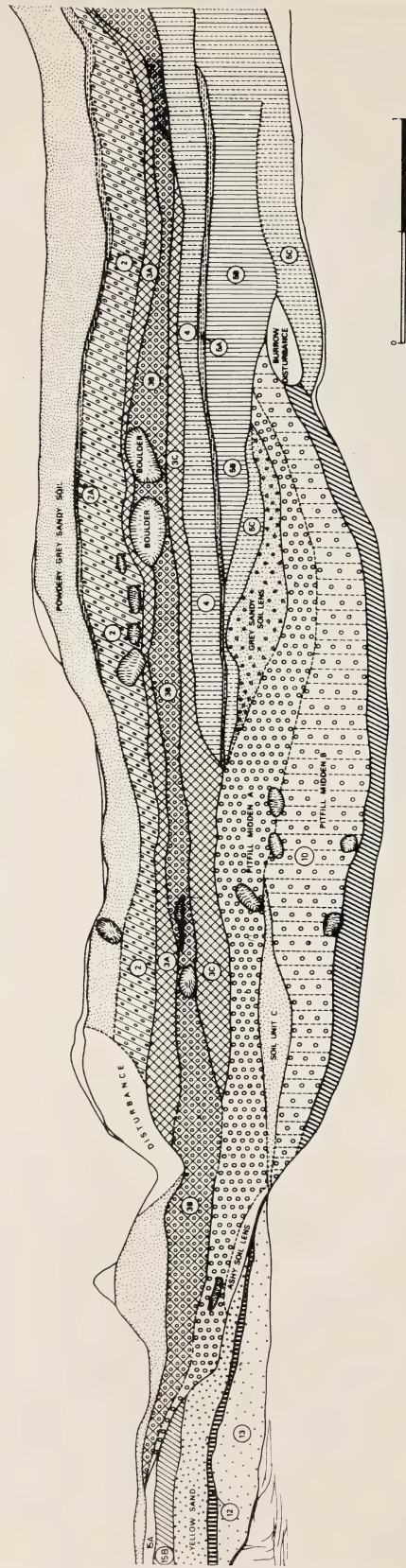


Fig. 6.



DK 1 EAST SECTION E2-AA2



C

Fig. 6.

DK1 NORTH SECTION OF SAMPA'S CAVE A1-A95

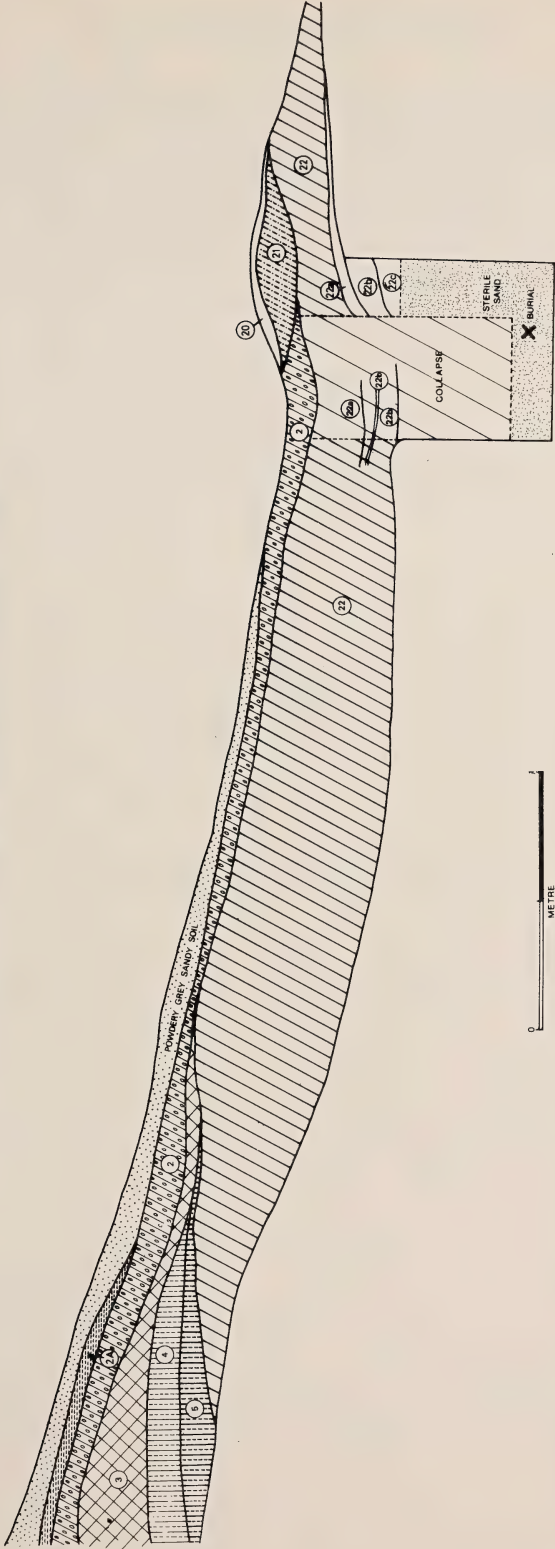


Fig. 6.

the midden surface. In the absence of any marked compaction, the middens still show irregular features related to the mode of accumulation on uneven surfaces and the complex micro-stratigraphy of the layers within the member required excavation with care. This is shown by the fact that during excavation some eighty minor subdivisions of this Holocene member were recognized and removed separately. For the purpose of analysis the excavated minor subdivisions were subsequently combined to form eleven composite or main layers. These layers can be grouped in three major divisions:

- (i) layer 12: this is an occupation soil, and the earliest deposit;
- (ii) layers 10–6 and 1: these shell-midden layers form the bulk of the thickness of the accumulation;
- (iii) layers 5–2: these shelly layers occupy surface irregularities in (ii); they may be contemporary with an accumulation, layer 22, recognized in a side passage of the cave.

#### DESCRIPTION OF MAIN LAYERS IN THE LATE HOLOCENE MIDDEN MEMBER

##### *Layer 12* (Figs 6 A–C, 7A)

The earliest occupation layer is clearly separated from the overlying layers by its brown, sandy matrix. The interface with the pink, shelly sand member was not everywhere sharp and thus may result in its having been mapped as slightly thicker than it, in fact, was. A date of  $1960 \pm 85$  B.P. (GX-1688) is associated with this layer, which extends over most of the area of the grid and has an average thickness of about 15 cm. Volume excavated was 3,1 m<sup>3</sup>. (Volumes of main layers excavated are shown in Fig. 9.)

##### *Layer 10* (Figs 6A–C, 7B)

This is essentially a shell layer resting on layer 12. It extends over most of the central gridded area with some irregularities in outline. The layer varies in thickness from 2 to 10 cm on the western side of the grid to 75 cm in the eastern section. This is a composite layer which was excavated as six sub-units which were subsequently grouped to form a single unit as they were seen to be part of a whole. Pitfill middens A and B (Fig. 6C) are included in layer 10. Volume excavated was 6,6 m<sup>3</sup>.

##### *Layer 9* (Fig. 7C)

This layer occupied the central area of the main grid and therefore does not appear on any of the section drawings. It was characterized by an orange-coloured sand matrix which helped to define its limits. This unit was of restricted size and included rock fragments within the shelly matrix. The maximum thickness was some 20 cm. The significance of the orange sand is difficult to interpret, but it has been regarded as a facies of layer 10 which surrounds it. Volume excavated was 1,4 m<sup>3</sup>.

*Layer 8 (Figs 6A-B, 7D)*

A shelly layer found in the south-western part of the excavation. It was originally excavated as four separate units which were subsequently grouped. Separation between this and layer 7 was not always clear and for practical purposes of inter-layer comparisons the contents of these two units can be considered together. An average thickness of about 45 cm was consistent in this horizon. Volume excavated was 3,2 m<sup>3</sup>.

*Layer 7 (Figs 6A-B, 7D)*

This was the most heterogeneous layer of the sequence. It was made up of predominantly ashy lenses and burnt shell deposits grouped on the western margins of the grid where it reached a thickness of 60 cm. It became more shelly in composition as it thinned out towards the centre of the grid area. Small lenses of pure sand occurred throughout this unit which was composed of a variable set of micro-stratigraphic midden entities. Volume excavated was 6,9 m<sup>3</sup>.

*Layer 6 (Figs 6B, 7E)*

This was a thin, sandy deposit generally not exceeding 10 cm in depth and blanketing part of layer 7. It was characterized by a white sand matrix with a relatively lower shell content. As in the case of layer 9, the distinguishing features may not warrant more than recognition as a facies of layer 7. Volume excavated was 1,4 m<sup>3</sup>.

*Layer 5 (Figs 1, 6B-D, 7F)*

This comprised a shelly layer restricted to the south-eastern part of the excavation. It formed the first deposit to fill in the hollow caused by the truncation of the earlier accumulation. This is shown in Figures 1 and 6B. As might be expected in a sloping deposit, the layer attained its maximum thickness of 35 cm at its base where it rested on the sterile sand floor of the deposit. Volume excavated was 1,6 m<sup>3</sup>.

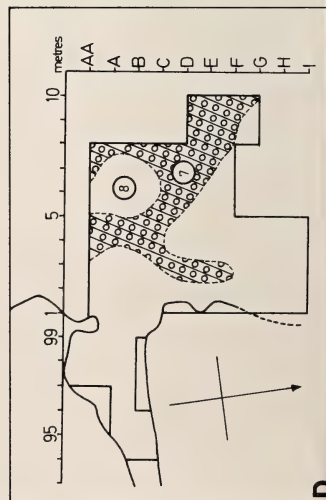
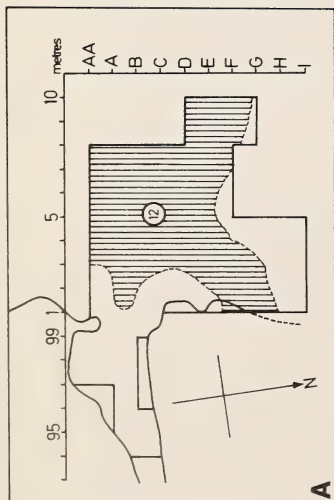
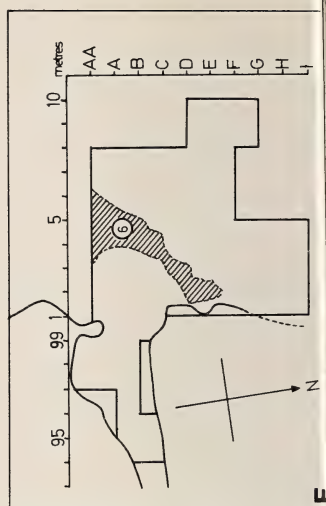
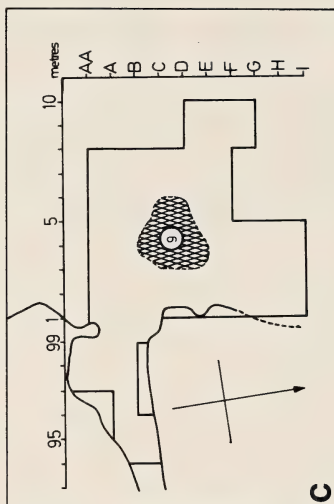
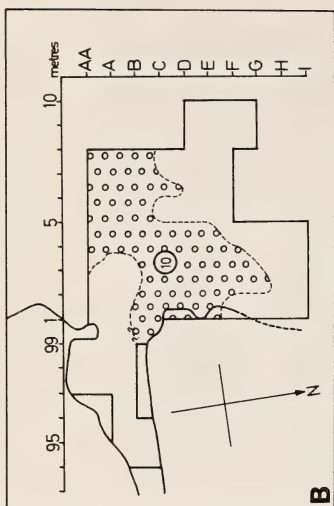
*Layer 4 (Figs 6B-D, 7G)*

This was a loosely compacted shell-midden, originally excavated as two sub-units, which formed the bulk of the in-fill of the above-mentioned hollow. This layer covered approximately the same area as layer 3 from which it differed mainly by virtue of its greater bulk and more lenticular shape. Its greatest depth was in the 'A' line where it attained a thickness of about 95 cm. Volume excavated was 4,5 m<sup>3</sup>.

*Layer 3 (Figs 6B-D, 7H)*

This layer was originally excavated as three sub-units consisting of a shell horizon lying between two thinner, brown sandy layers. Maximum thickness occurred in the lower eastern part of the deposit. Volume excavated was 2,5 m<sup>3</sup>.





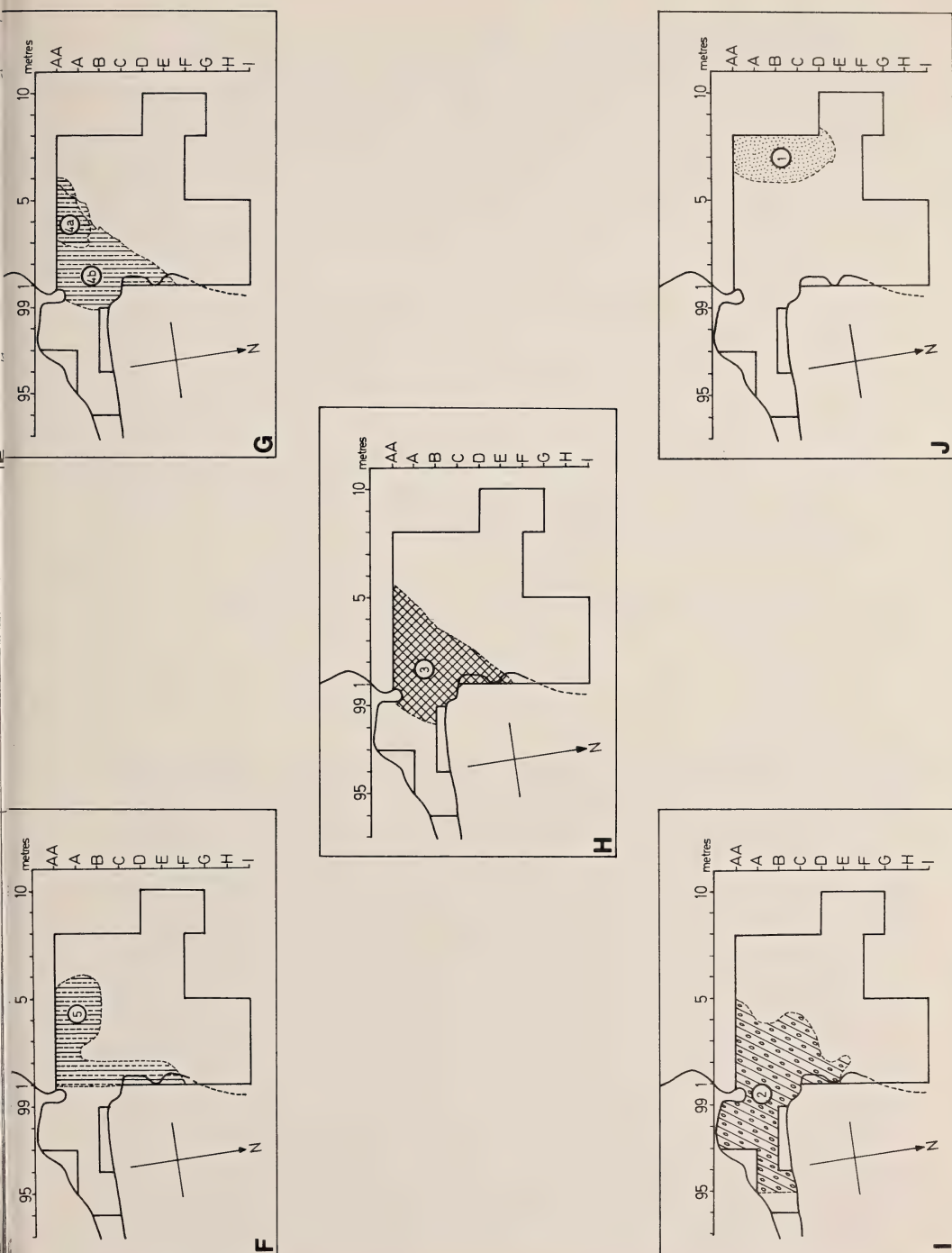


Fig. 7. DK 1, plans of excavation. A. Layer 12. B. Layer 10. C. Layer 9. D. Layers 8 and 7. E. Layer 6. F. Layer 5. G. Layer 4. H. Layer 3. I. Layer 2. J. Layer 1.

*Layer 2 (Figs 6B–D, 7I)*

The uppermost shell-midden of the south-eastern sequence followed the general easterly dip of the underlying layers. Its limits were readily recognizable owing to the contrasting sandy matrix of the adjoining layers. It was superficially indistinguishable from the other shell-middens but was unique in that it contained by far the greatest number of domestic animal bones. It was originally excavated in two parts, 2*a* and 2*b*, and varied in thickness from 6 to 20 cm. Volume excavated was *c.* 5 m<sup>3</sup>.

*Layer 1 (Figs 6A–B, 7J)*

This was a somewhat complex layer consisting of a shell-midden in the south-western part of the excavation and included the adjoining thicker deposits originally designated layer 17 in the western limits of the grid. It may be argued that the south-western part of layer 1 should be grouped with layer 2 which it resembles more than the facies in the western part. However, in the absence of an acceptable stratigraphic correlation between layers 1 and 2 they have been kept separate. By including the layer 17 material in layer 1, a unit large enough for comparison was obtained without distortion of the stratigraphic record. Volume excavated was *c.*  $0,2 + 0,9 \text{ m}^3 = 1,1 \text{ m}^3$ .

## DESCRIPTION OF MINOR LAYERS IN THE LATE HOLOCENE MIDDEN MEMBER

*Layer 11*

This layer consisted of a localized lens of white sand which for convenience was incorporated into layer 6 during the course of the excavation. It is, therefore, not treated as a separate layer in this report.

*Layer 15a (Fig. 6C)*

A small localized shell-midden, the youngest deposit in the north-eastern part of the grid.

*Layer 15b (Fig. 6C)*

A patch of ashy soil below 15*a*.

*Yellow sand (Fig. 6C)*

A sandy layer blanketing a thin outlier of layer 12 and the Middle Stone Age (M.S.A.) deposits where these surface near the drip-line. Disturbances may have caused some mixing of horizons in this part of the midden.

*Layers 20, 22 and 22a–c (Fig. 6D)*

Shell-middens situated well within 'Sampa's cave', which were excavated separately. The position of layer 22 alongside layers 5–2 would suggest that it was contemporary with these horizons. The layer was predominantly composed of shell which is noticeably less fragmented than that in the higher-roofed main chamber of the cave. It contained the dispersed bones of two human skeletons,



both of which lack skulls. This demonstrates the degree of disturbance that must have taken place in the midden during its accumulation. As indicated in Figure 6D, a collapse of the deposit overlying the burial occurred during removal of these layers.

#### GENERAL DISCUSSION OF THE STRATIGRAPHY

The stratigraphy of DK 1 reveals a clear-cut distinction between layer 12, which is an occupation horizon, and the remainder of the deposits, which consist of refuse heaps. The latter show signs of having been disturbed in various ways subsequent to their deposition. Evidence for disturbance comes from the scattered human skeletal remains in layer 22 and the distribution of potsherds and tortoise carapace fragments that could be joined but which were found in adjacent squares and even layers. There was a greater concentration of ash lenses in the western limits of the grid and these could, in part, represent burnt organic material such as bedding. No clear evidence of sleeping hollows was found, but *Zostera capensis*, which can be interpreted as having been introduced for bedding, occurred in small clumps throughout the sequence. It would seem, then, that the sections of the cave exposed through excavation reveal the result of intermittent occupation by people following a similar basic adaptation to coastal living. Occupation was probably spread to a greater or lesser degree over the whole cave floor and the relatively small excavation samples part of this shifting pattern of floor usage. The whole would be revealed only by a considerably more extensive excavation, beyond the scope of the present project.



Fig. 8. DK 1, east section before opening of Sampa's cave (right of staff).



## DATING AND CORRELATION

Nine radiocarbon dates have been obtained for the Holocene occupation of DK 1 (Table 1). The first four charcoal samples to be dated were submitted to Geochron Laboratories (GX-1685-8) in 1969 and showed that the midden had accumulated between 1 500 and 2 000 years ago. A second series of four charcoal samples (GaK-3877-8, GaK-3955-6) was sent to the Gakushuin Laboratory in 1972 in order to verify the unexpectedly early dates for domestic sheep remains at the site. A further series of samples was submitted to the University of Washington laboratory in Seattle to determine the lapse of time

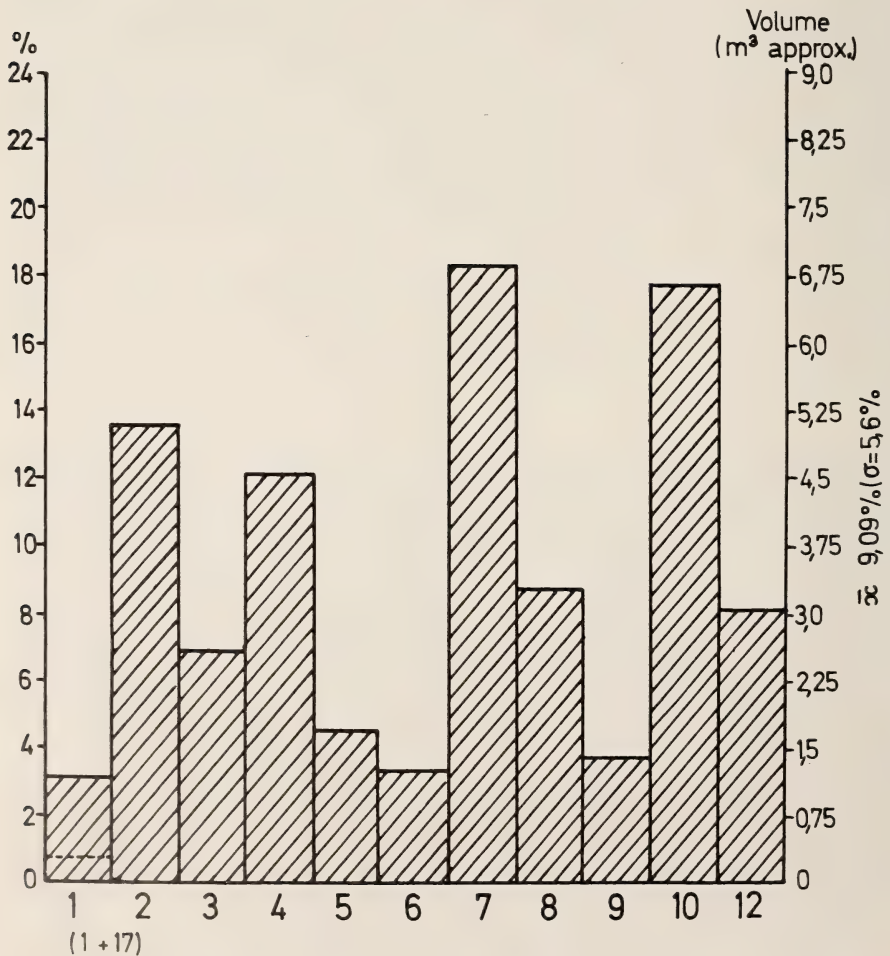


Fig. 9. Histogram of volume of excavated material from individual layers.

TABLE 1  
Radiocarbon dates for occupation layers.

<i>Layer</i>	<i>Lab. no.</i>	<i>Years B.P. (5568 year half-life)</i>	<i>Years B.P. (5730 year half-life)</i>	<i>Date</i>
2 . . . . .	GX-1685	1465 $\pm$ 100	1509 $\pm$ 100	A.D. 441
	GaK-3955	1600 $\pm$ 120	1648 $\pm$ 120	A.D. 302
	GaK-3877*	1650 $\pm$ 90	1699 $\pm$ 90	A.D. 251
	GaK-3878*	2620 $\pm$ 100	2699 $\pm$ 100	B.C. 749
3 . . . . .	GaK-3956	1590 $\pm$ 80	1638 $\pm$ 80	A.D. 312
4 . . . . .	GX-1686	2020 $\pm$ 95	2080 $\pm$ 95	B.C. 130
	UW-291*	1480 $\pm$ 55	1524 $\pm$ 55	A.D. 426
7/9 . . . . .	GX-1687	1960 $\pm$ 95	2019 $\pm$ 95	B.C. 69
12 . . . . .	GX-1688	1960 $\pm$ 85	2019 $\pm$ 85	B.C. 69

\* Dates marked with an asterisk were derived from charcoal fragments collected from sieves after washing, and are considered less reliable.

represented by the truncation of layers 7 and 8 and the subsequent deposition of layers 5 and 4. Only one of these samples has so far been processed (UW-291).

The radiocarbon age determinations at present available show reasonable stratigraphic consistency. Two clusters of dates are apparent. The earlier cluster relates to layer 12-9 and gives results of the order of 2000 years B.P. The later cluster gives results between 1650 and 1465 years B.P., suggesting that the upper midden layers would span the fourth to fifth centuries A.D. That there were two discrete periods of occupation is an important conclusion because of the contrasts between layers 12 and 2, representing phases prior and subsequent to the introduction of domestic stock to the area.

The dates are not completely consistent. In the later cluster GaK-3878, dating layer 2, is anomalously old. This could be due to sampling—the sample was collected from a screen and not directly out of the deposit and it came from a square not fully covered by layer 2 in which an older (M.S.A.) horizon also surfaces. Sample GX-1686 from layer 4 is also apparently too old and the dating fits the earlier series better than the later series. There is no easy explanation for this anomaly. The remaining five dates cluster very closely and it would seem reasonable to accept them as the best estimate of the age of layers 2-4. As noted by Vogel (1969: 86) conclusions on radiocarbon dates depend on series of dates rather than on isolated determinations. The DK 1 dates have established a basis for the introduction of herding in the south-western Cape which has been supported by other more recent discoveries.

#### EXCAVATION PROCEDURE

Prior to the excavation, the cave was surveyed and plans, which included contour lines, were drawn. Two base lines at right angles to each other were

laid out on the deposit and their positions were fixed on the cave roof by means of eight brass hooks. This enabled the rapid and accurate resetting of the original base lines at the beginning of subsequent extensions of the excavations by suspending plumb lines from the roof hooks. The base lines, which formed two sides of the first excavation, were marked off in 1-metre intervals which were lettered in one direction and numbered in the other (Fig. 7A-J). This gave a primary grid of 1-metre markers for horizontal location.

The excavation was carried out using trowels and paint-brushes. All the material recovered was dry-sieved on a double-tiered rack with a 13 mm mesh sieve above one of 3 mm mesh. With the exception of soil and shell, which were regularly sampled, all the material collected in the sieves was retained for later laboratory examination. The volume of all shell recovered from sieving the different layers was also recorded (Table 19).

Below the superficial unstratified material, the midden structure was well preserved and layers were traced individually and methodically removed from each square metre over their entire extent within the confines of the grid. During later excavations, when there were guidelines from earlier drawn sections, the approach varied from excavating single 1-metre squares through all the strata (1970-1), to following single layers over many squares (1972).

Section drawing procedures varied during the progress of the excavations: either faces of individual metre squares were drawn as excavated, or the face of several metre squares was drawn as an entity. Plans and other records were made during the course of excavation according to standard procedure. The positions of special features were recorded in plan and section as necessary. Drawings were augmented by black-and-white and colour-slide photography. The ample sunlight entering the north-facing cave gave sufficient light for excavation purposes. The exception was when, in the search for additional sheep remains, the excavation was extended into the narrow passage, 'Sampa's cave', in the far eastern corner of the grid. There it was found necessary to use artificial light and this was somewhat less satisfactory.

For purposes of preservation the vertical sections of the excavation have since been protected by sand-bags.

#### ARTEFACTUAL FINDS

The artefacts from DK 1 were made of various raw materials. The non-lithic assemblage consists of bone and shell artefacts and pottery. No wooden implements were found. Had wooden tools been left at the site they would probably have been preserved, since preservation of other materials is good. This is shown by finds of remnant patches of the sea-grass *Zostera capensis* in all layers.

As seems usual in the late Holocene coastal midden deposits that have been excavated, the stone artefacts are limited in the range of forms represented and in quality of retouch. Had they not been found associated with midden material many of them might have not been recognized as objects modified by



man. For the most part the stone artefacts consist of rough, flaked beach cobbles and the flake products from such cores. On the other hand, artefacts manufactured from other materials, particularly in bone and shell, are varied and formalized and the initial Holocene occupation of DK 1 (layer 12) indicates the existence of an already established pottery tradition.

All the material in this paper bears the main accession number SAM-AA8725. Numbers in the figure legends are those of individual finds from this excavation.

## BONE ARTEFACTS

### *Introduction*

That bone artefacts are well represented at coastal midden sites in the Cape has been long appreciated. Péringuey (1911: 97) attempted the first systematic typological analysis of bone artefact collections from shell mounds, caves and rock-shelters between the Cape Peninsula and the Tsitsikama coast over 60 years ago. He recorded rare 'knives', numerous 'awls' and 'arrow points', and noted that it was only on artefacts of bird bone that decorative marks were found. It is doubtful whether the typological classes of Péringuey still provide a basis for the adequate description of the range of bone tools found at Cape coastal sites and his typology is now more of historical interest. Encouraged by Péringuey, Sharples carried out extensive excavations at Plettenberg Bay in 1917 (Rudner & Rudner 1973: 94) and considerably enlarged the collection of bone artefacts now housed in the South African Museum. These and subsequent excavations, notably by Goodwin (1938*b*) at Oakhurst and Dreyer at Matjes River (Louw 1960), have confirmed the relatively elaborate technology of bone-working practised by the coastal dwellers. These earlier collections are, however, almost unstudied and the paucity of information on context and dating raises doubts as to the value of detailed study. A renewed phase of excavation at coastal sites in the last decade promises to provide better-controlled samples and reassessment of the earlier collections may be possible in relation to the newly generated samples such as those from Die Kelders.

### *The typology of the bone artefact sample*

Bone artefacts occurred throughout the Holocene deposits at DK 1. Of the 383 pieces recovered, 238 were whole or broken formal tools and ornaments; the other 145 pieces were fragments, splinters and teeth showing signs of modification. One complete tortoise carapace bowl and fragments of many others were also recovered. Because of the generally good bone preservation at the site, the only items requiring treatment were a number of exfoliating pieces of ivory. In direct contrast to the lithic assemblage, most of the bone artefacts were made to formal designs and this facilitates the interpretation of function. A high degree of craftsmanship is evident in the manufacture of various tool types from diverse animal bones. Bird bones provided a good source for light



shafts whilst the denser mammal bone supplied material for more durable tools such as projectile points and spatulae. Similarly, awls were made mainly from mammal bone with only occasional examples in bird or fish bone.

### *Formal tool classes*

The following formal classes of bone tools have been recognized and the frequencies of the finds in the different classes are given in Table 2.

#### *Projectile parts*

1. *Points* (Fig. 10). These were made by shaping both ends and working most or all of the surface of a bone splinter to form a tool with a finely tapering, pointed tip at one end and a squared-off butt or blunter point at the other. They are usually well finished, slender tools with a relatively uniform diameter for most of their length. The sample from DK 1 consists of two size categories: longer points ranging from 160 to 170 mm in length and having an average maximum diameter of 6 mm, and smaller points ranging from 40 mm to 100 mm in length with maximum diameters ranging between 3 and 6 mm. Broken points have been listed separately in Table 2.

2. *Linkshafts* (Fig. 11A–D). These are somewhat bigger, thicker and more cigar-shaped pieces. They often have flat mid-sections due to the shape of the original bone splinter from which they were made. Broken linkshafts are given separate listing in Table 2.

3. *Unclassified points or linkshafts*. These include pieces which fall between the two recognizable classes and cannot be assigned to one or the other with any certainty. Broken pieces, usually rounded, thin bone splinters with both ends missing, that apparently fall into this class have also been listed separately in Table 2.

The ready division of bone projectile parts into points and linkshafts suggests a close correspondence to the composite Bushman reed arrows described by Goodwin & Van Riet Lowe (1929: 254): 'The foremost part consists of the point, a splinter of bone rounded, and sharpened at the forward end, measuring about 7 cm in length by 4 mm at its greatest thickness. The butt, which is squared off, is bound into a reed collar, and rests directly against the forward point of the linkshaft, which is also bound into the reed collar. The collar usually measures 15 mm in length by 7 mm diameter. The linkshaft consists of a rounded splinter of bone, pointed at each end, and measuring some 6 cm in length by 1 cm in thickness. The hinder end is inserted into the reed shaft of the arrow, which measures perhaps 40 cm in length. The point is poisoned and the whole foreshaft can be reversed in the reed arrow to guard the poisoned point when not in use.'

#### *Spatulae*

These are made of long pieces of bone and have been generally assumed to be skin-working tools. They are subdivided into the following types.



Fig. 10. Bone points: size range. A. SAM-AA1930 layer 2. B. SAM-AA1542 layer 2. C. SAM-AA2674 layer 5. D. SAM-AA316 layer 12. E. SAM-AA2979 layer 1.

TABLE 2  
Bone: implements.

Layer	1	2	3	4	5	6	7	8	9	10	12	10* and	12	15	20	22	22b	Total	% grand total
Points, whole	—	3	1	—	—	—	1	—	—	—	—	—	10	1	—	—	—	16	4,2
Points, broken	1	4	—	—	—	—	2	—	—	2	—	—	7	—	—	—	—	16	4,2
Linkshafts, whole	1	2	—	1	2	1	1	—	—	1	—	—	4	—	—	1	—	14	3,6
Linkshafts, broken	—	5	—	1	—	—	2	—	—	2	—	—	10	—	—	1	—	21	5,4
Possible points or linkshafts, whole	—	—	—	—	—	—	—	—	—	—	—	—	2	1	—	—	—	3	0,8
Possible points or linkshafts, broken	—	1	—	—	—	—	2	—	—	1	1	—	2	—	1	1	—	9	2,3
Spatulae, flat, whole	—	8	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	8	2,1
Spatulae, flat, broken	—	5	1	—	—	—	2	—	—	—	—	—	—	—	—	—	—	8	2,1
Spatulae, round, whole	—	1	—	1	—	—	—	—	—	—	—	—	2	—	—	—	—	4	1,0
Spatulae, round, broken	—	—	—	—	1	—	2	—	—	1	1	—	—	—	—	—	—	5	1,3
'Spoons'	1	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2	0,5
Awls, whole	7	8	—	21	1	2	19	3	3	16	—	—	17	3	2	3	1	106	27,5
Awls, broken	—	2	—	—	—	—	1	1	2	—	—	—	—	—	—	—	—	6	1,6
Awls, needle	—	—	—	1	—	—	—	2	—	1	—	—	2	—	—	—	—	6	1,6
Utilized splinters	—	1	—	1	—	—	—	—	—	—	5	—	6	—	—	1	—	14	3,6
Utilized scapulae	—	5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	5	1,3
Utilized sternum	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	0,3
Utilized teeth	—	—	—	—	—	—	—	—	—	—	—	—	3	—	—	—	—	3	0,8
Utilized ivory (bracelet)	—	—	—	—	—	—	—	—	—	—	—	—	2	—	—	—	—	2	0,5
Utilized various	6	10	4	6	1	1	12	1	4	9	1	—	64	—	—	1	—	120	31,2
Ornaments, tubes	—	2	—	1	1	—	2	—	—	1	—	—	5	—	—	2	—	14	3,6
Ornaments, rings	—	—	—	—	—	—	—	—	—	—	—	—	2	—	—	—	—	2	0,5
Total	16	59	6	33	6	4	46	7	9	34	8	138	5	3	10	1	385		
% of grand total	4,2	15,3	1,6	8,6	1,6	1,0	11,9	1,8	2,3	8,8	2,1	35,8	1,3	0,8	2,6	0,3		100,0	

\* Junction of layers 10 and 12.

1. *Flat spatulae* (Fig. 12A–B) which are made of the ribs of large mammals, with one end square, bevelled and polished by usage; the size range lies between 110 and 220 mm.

2. *Round spatulae* (Fig. 12C–E) which are similar to the above but round, sometimes made of ivory with blunt, not chisel-edged, ends; the size range lies between 100 and 140 mm.

### *Spoons*

Two pieces of rib, shaped into 'spoons', were found in the upper midden layers. The more finely worked one (Fig. 13A) came from layer 2, where it was

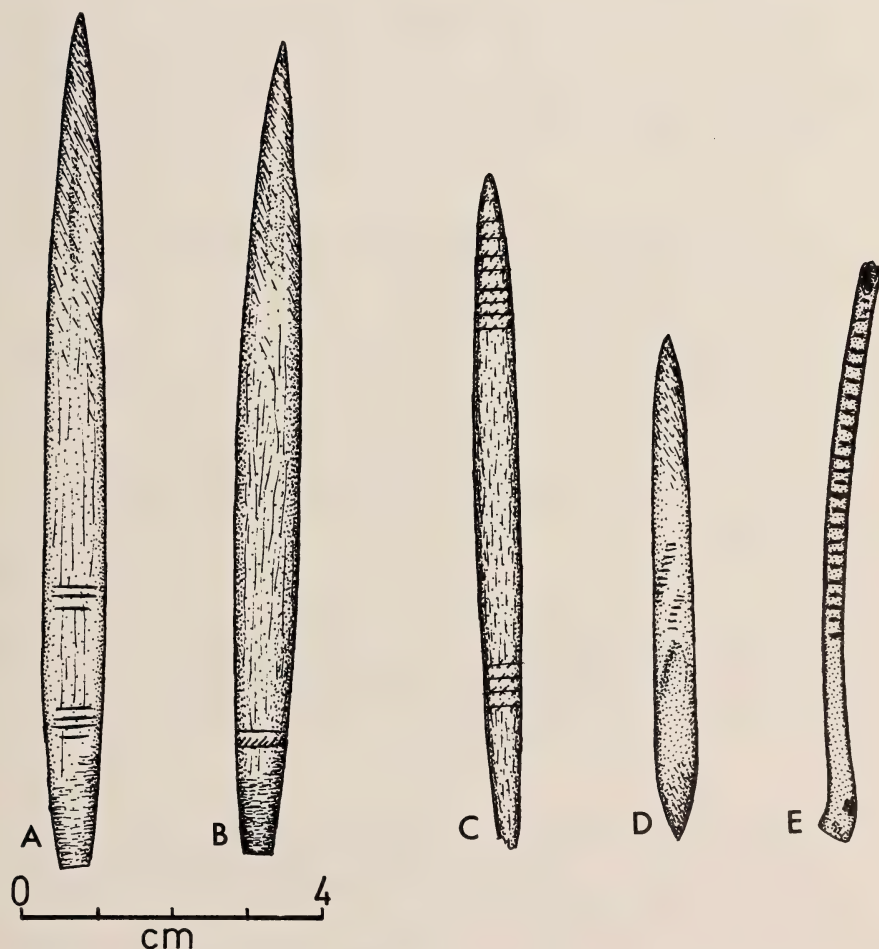


Fig. 11. Incised bone. Linkshafts A–D. A. SAM-AA1358 layer 12. B. SAM-AA1034 layer 12. C. SAM-AA1540 layer 2. D. SAM-AA3314 layer 2. E. Notched, hollow bird bone, SAM-AA2438 layer 5.



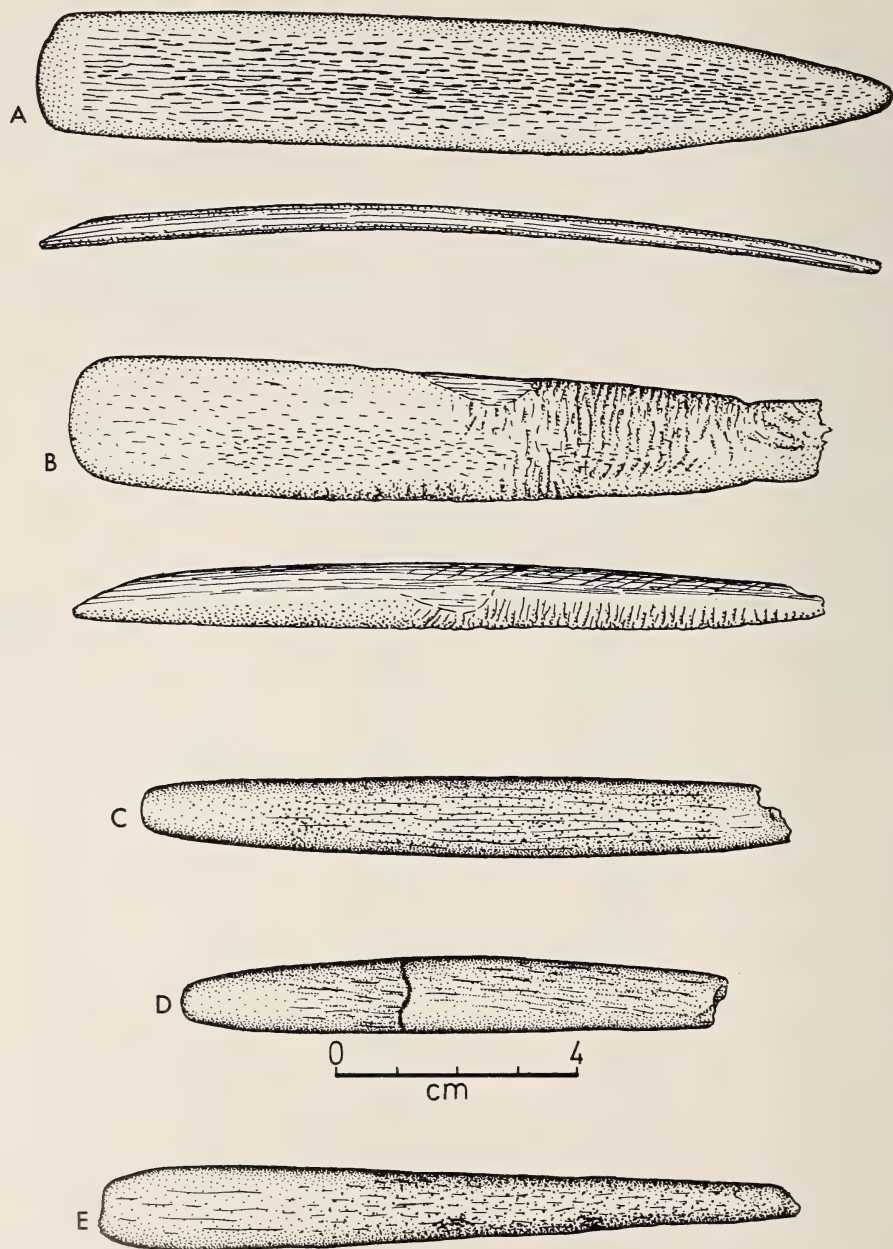


Fig. 12. Bone spatulae. Flat, made of ribs: A. SAM-AA3285 layer 2. B. SAM-AA3397 layer 2. Rounded, made of ivory: C. SAM-AA2022 layer 7. D. SAM-AA1685 layer 7. E. SAM-AA753 layer 10.

found in close proximity to the small tortoise carapace bowl illustrated in Figure 19. The other 'spoon', less well shaped (Fig. 13B), came from layer 1.

### *Awls*

This category includes all tools made by sharpening one end of a bone fragment to a point suitable for piercing holes. There is considerable variation in size, kind of bone, and the degree of finish. The emphasis is always on the point which in many examples is polished by use and it is rarely that the rest of the tool shows any modification. Awls have been subdivided into the following categories.

1. *Common awls* (Fig. 14C–N) which include those with a shaft considerably thicker than their points.

2. *Needle awls* (Fig. 14A–B) which are small, thin, finely tapering pieces with a mean overall diameter of 1–2 mm. They are classed separately from common awls by virtue of their thinness which would have precluded their use for the same purposes as common awls.

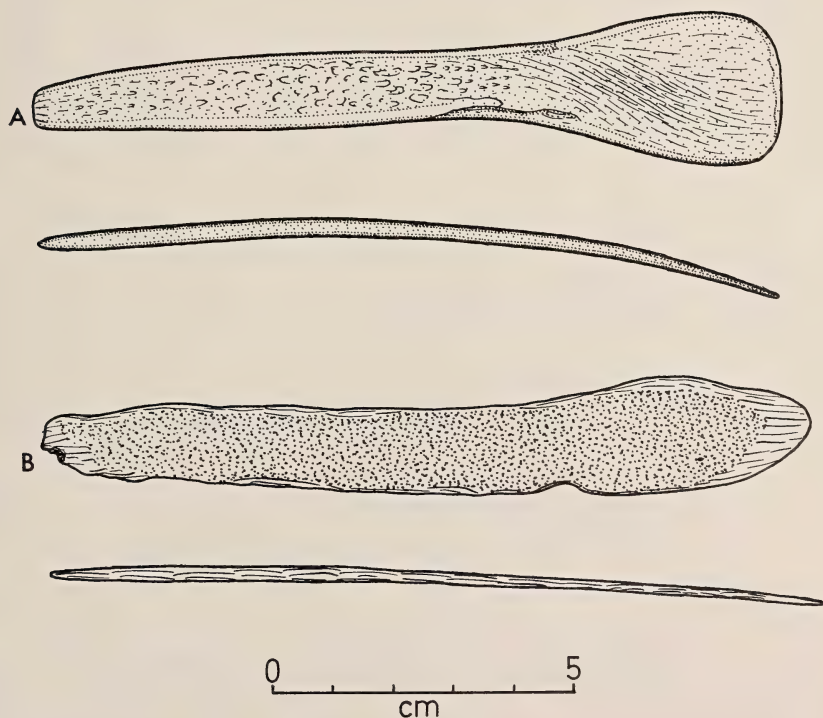


Fig. 13. Bone 'spoons'. A. SAM-AA210 layer 2. B. SAM-AA2013 layer 1.

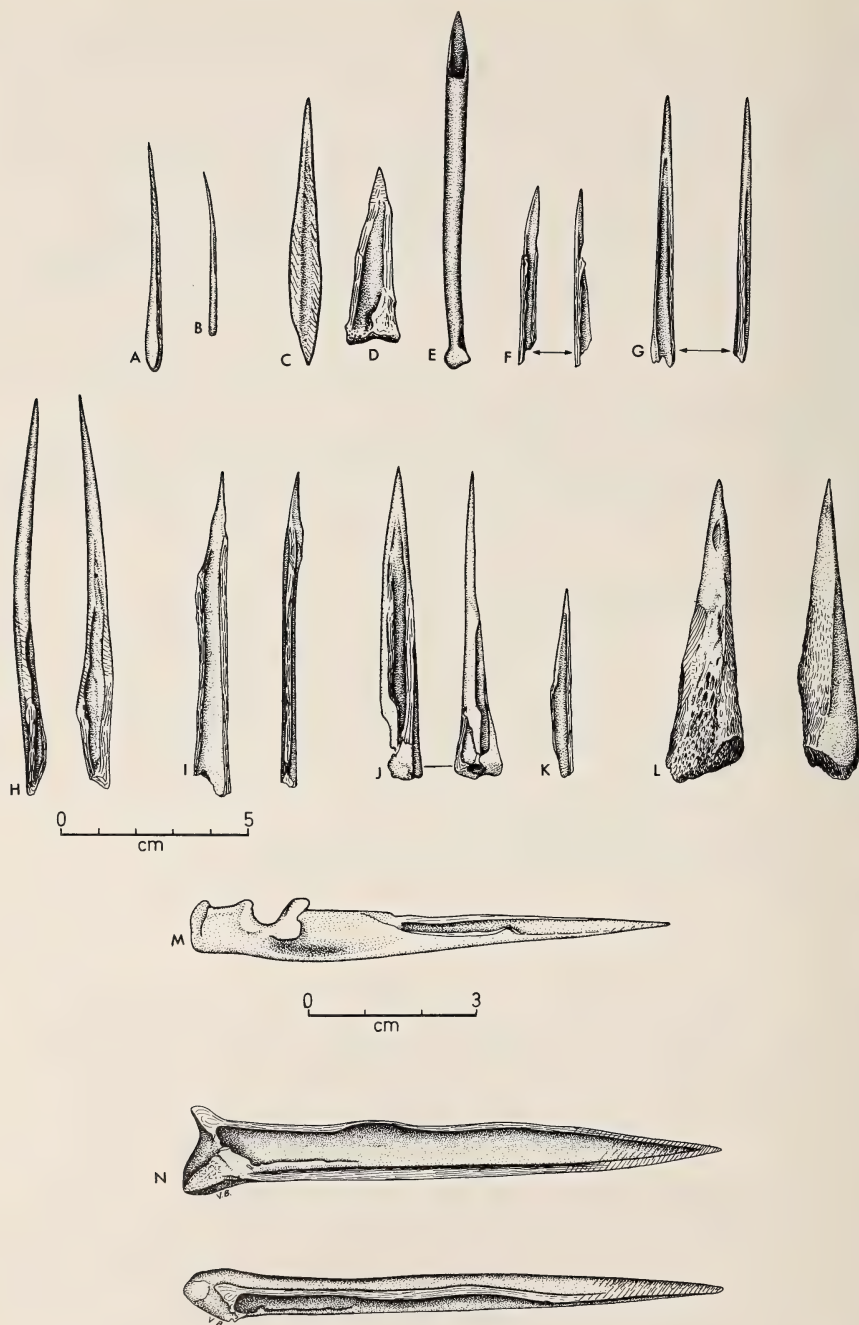


Fig. 14. Bone awls showing range in shape and size. A. Needle awl, SAM-AA2579 layer 10. B. Needle awl, SAM-AA1164 layer 6. C. SAM-AA1541 layer 2. D. SAM-AA450 layer 6. E. Bird-bone awl, SAM-AA1842 layer 1. F. SAM-AA291 layer 10. G. SAM-AA443 layer 10. H. SAM-AA284 layer 10. I. SAM-AA273 layer 10. J. SAM-AA1869 layer 1. K. SAM-AA1657 layer 1. L. SAM-AA3409 layer 2. M. SAM-AA1561 layer 1. N. SAM-AA1359 layer 12.

### *Utilized pieces*

This category includes ivory, bird, fish and mammal bone, all of which bear evidence of having been worked to some extent.

1. *Modified fragments* (Fig. 15) of mammal bone which show modification along their length by flaking, in addition to polish at their ends; this pattern of usage suggests their function as skin-working implements.

2. *Scapulae of sheep* (Fig. 16) and a possible seal sternum that show utilization on the long edges; the edge damage suggests that these tools were used for scraping.

3. *Animal teeth* consisting of a leopard tooth (Fig. 17A), a baboon tooth (Fig. 17B), and a pig tusk, which show signs of utilization on their crowns.

4. *Miscellaneous utilized pieces* consisting of fragments of other pieces, unfinished pieces, possible off-cuts, and pieces bearing signs of random usage.

### *Ornaments*

1. *Tubes* (Fig. 18A–B) are cut lengths of hollow bone ranging in size from  $20 \times 5$  mm to  $80 \times 10$  mm. Both bird and mammal bones were used. Ends often retain evidence of having been snap-broken after ring-grooving (Fig. 18C). Some of these pieces are highly polished, possibly as a result of having been used as beads.

2. *Rings* (Fig. 18D) are flat pieces made of the cross-section of hollow bone. Included here is a possible bracelet of ivory. Ivory does not preserve well, tending to break up into concentric rings, and pieces of 'rotten' (weathered) ivory were recovered from layer 2.

### *Tortoise carapace bowls*

Bowls or parts of bowls were found in almost all layers. These were made by removing the plastron, flattening the spinal protrusions, and rounding and smoothing the resulting edge of the bowl. The finds are listed in Table 3, and an example is shown in Figure 19. Counts are given in terms of complete bowls, broken bowls (where about half the bowl is preserved), and bowl fragments, which include modified pieces of carapace (between one and five plates) that show the characteristic tooling marks or working of a bowl. The bowl fragments have been studied in detail to determine whether they could have come from one of more bowls in any level. The approximate count of bowls represented by modified carapace fragments is included in the total bowl counts.

### *Discussion of the bone artefacts*

From Table 2 it can be seen that awls (118) are by far the most common type of bone tool. Parts of projectile points, arrow-heads, linkshafts, bowls and spatulae are also well represented. The formal artefacts are not restricted to any horizon. Layers 2, 5 and 12 yielded relatively more projectile pieces and in layer 2 the greatest variety of points was found. Needle awls are not common



and appear to be restricted to the layers below layer 4. Their apparent absence from the upper layers may, however, be due to sampling factors. There is some suggestion of a time trend in the replacement of the round form of spatula by the flat form above layer 4, and the latter form is best represented in layer 2. There are certainly stylistic changes in the pottery between the lower and upper levels of the midden accumulation, and parallel changes in the bone tools would not be unexpected.

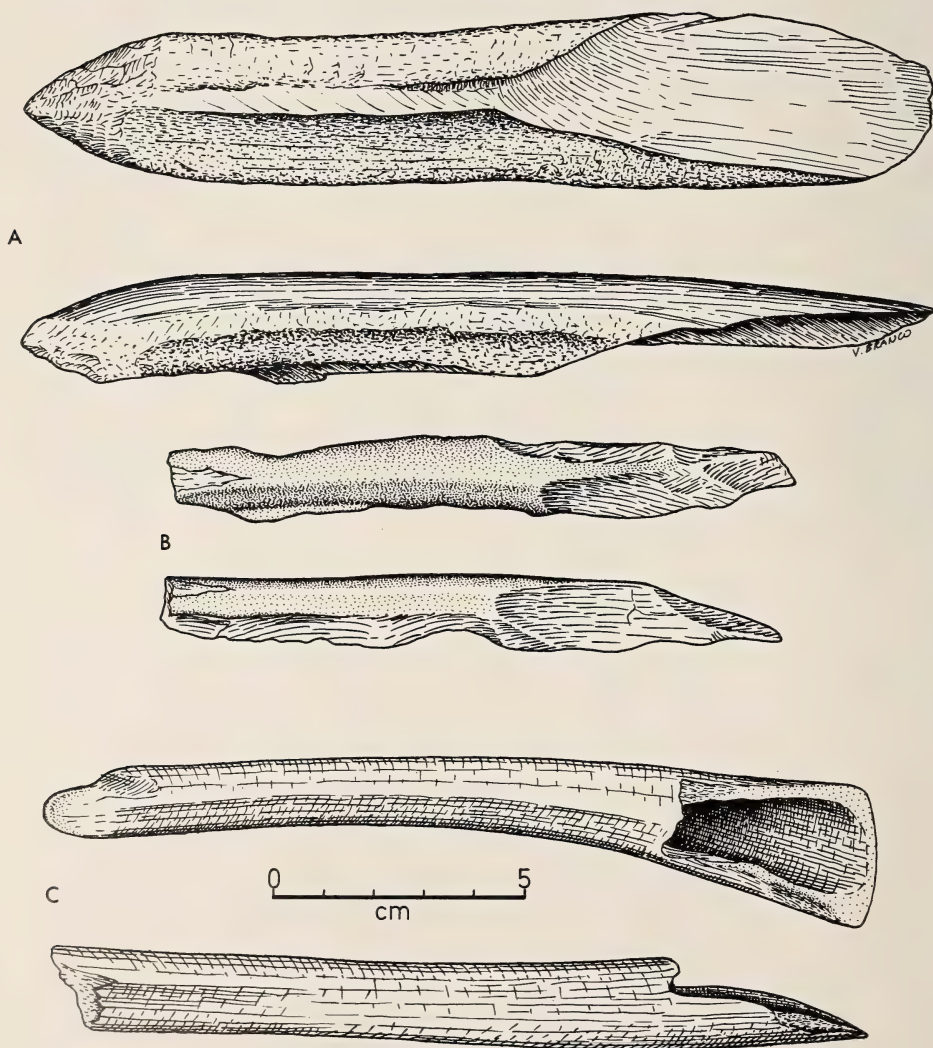


Fig. 15 Tools possibly used as spatulae. A. Ivory, SAM-AA3315 layer 2. B. Bone, SAM-AA330 layer 4. C. Bone, SAM-AA3289 layer 2.

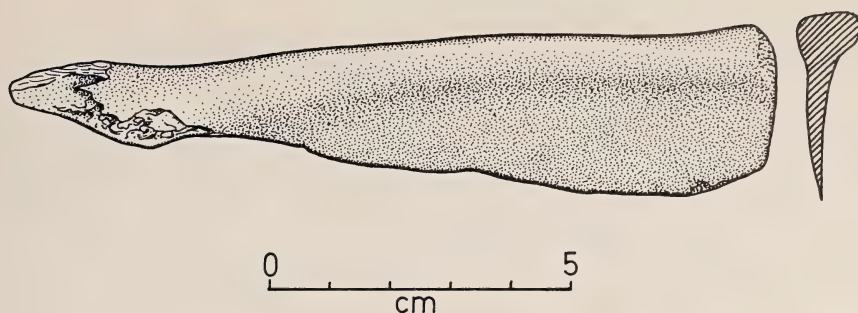


Fig. 16. Utilized sheep scapula, SAM-AA856 layer 2.

The functional interpretation of the bone points and linkshafts would seem to be well supported by ethnographic analogy. The composite arrow-head was known historically to have been widely diffused in southern Africa and this is suggestive of its being in use for a long time. It is a specialized artefact associated with the use of a weak bow and relying rather on the lethal effect of poisons than of penetration. The artefactual bone finds give direct evidence for this kind of projectile hunting which was usually directed at the medium and larger antelope. In addition to the more or less uniform length (*c.* 70 mm) of the arrow points found throughout the deposit, layer 2 contained two long arrow-heads (Fig. 10) of about twice the normal length (195–205 mm) which may have been directly fitted on to a wooden point such as that from Scott's Cave in the eastern Cape (Deacon & Deacon 1963: 114–151). One broken and

TABLE 3  
Bone: tortoise carapace bowls.

Layer	Complete	Broken	Modified fragments	Bowls represented by modified fragments	Total bowls
1 . . . . .	—	—	—	—	—
2 . . . . .	1	—	6	2	3
3 . . . . .	—	2	8	4	6
4 . . . . .	—	2*	11	3	5
5 . . . . .	—	—	—	—	—
6 . . . . .	—	—	1	—	—
7 . . . . .	—	1	—	—	1
8 . . . . .	—	1	—	—	1
9 . . . . .	—	—	1	—	—
10 . . . . .	—	4	—	2	6
12 . . . . .	—	1	±20	4	5
15b . . . . .	—	—	—	—	—
22 . . . . .	—	—	—	2	2
Total . . . . .	1	11	—	17	±29

\* Includes the *Testudo geometrica* carapace.

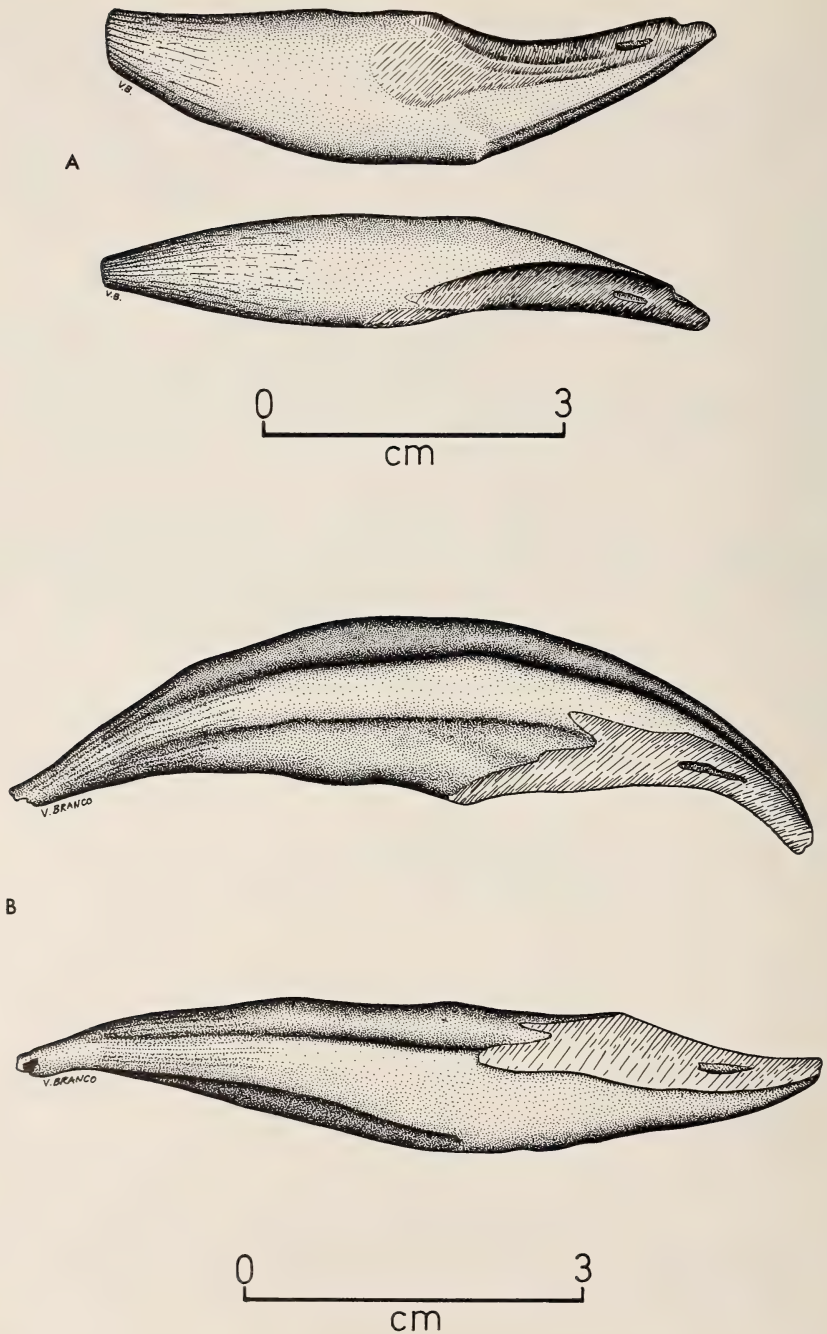


Fig. 17. Utilized animal teeth. A. Leopard tooth, SAM-AA1846 layer 12. B. Baboon tooth, SAM-AA1847 layer 12.



four complete linkshafts show interesting decoration, which is incised and varies from piece to piece (Fig. 11A–D); the decorations are not directly functional and may well be marks of ownership.

The large number of awls suggests that the manufacture of skin garments was important. The slender needle awls may have had a different function and, indeed, they would have been most suitable for sewing the thin skins of dune mole-rats, but would have been too fragile for working the heavier skins of seal or sheep. The apparent absence of needle awls in the upper layers may also be explained by a lesser demand for dune mole-rat skins when sheep skins became more readily available.

The category of utilized bone includes a notched bird bone shaft (Fig. 11E) which is noteworthy because of its similarity to at least two other such incised bone artefacts from other sites along the south-western Cape coast (Maggs & Speed 1967: 83; Van Noten 1974: 129). This suggests that it may be of value to look for repeated incised patterns in Cape coastal sites and wider study may offer some explanation of their function. The few examples of animal teeth included in the utilized bone category show utilization marks on restricted surfaces and are somewhat anomalous 'osteodontokeratic' elements. The utilization marks on these teeth are in marked contrast to the other implements in this category which do not show comparable localization of wear.

Ornaments do not constitute an important part of the bone industry. Tubes were made by snapping the base of ring-cut shafts (Fig. 18C), using a technique similar to that used for working wood at Melkhoutboom Cave, eastern Cape (Deacon, H. J. 1969: 149). These similarities suggest that the extensive bone industry at DK 1 to some extent replaced the use of wood at more inland sites.

The use of tortoise carapace bowls as containers is supported by ethnographic observations and amongst groups such as the Nharo Bushmen these are still in use as receptacles for aromatic powders. They are often decorated and worn on a thong round the neck (Steyn 1971: 293). There is also evidence of their use as food receptacles (E. M. Shaw pers. comm.). They may have served both purposes at DK 1 as is shown by the presence of a bored carapace fragment in layer 7, the occurrence of four bowls in close association in layer 3, and the association of a bone 'spoon' (Fig. 13A) with a further bowl in layer 2. Not all the tortoise remains found at the site were the result of bowl-making; a large number of carapace fragments do not show modification, and tortoises are a well-known source of food. Of interest, and included among the bowls, is a broken example made of the carapace of *Testudo geometrica*. The present known distribution of this now rare species is restricted approximately to the lowland areas (below 300 m) between Piketberg, Worcester and Gordon's Bay (R. Rau pers. comm.). Although the past distribution of *T. geometrica* is unknown, the occurrence of a carapace of this species at DK 1 may indicate the extent of the seasonal (?) round of the cave occupants, or contact with other groups from these areas.



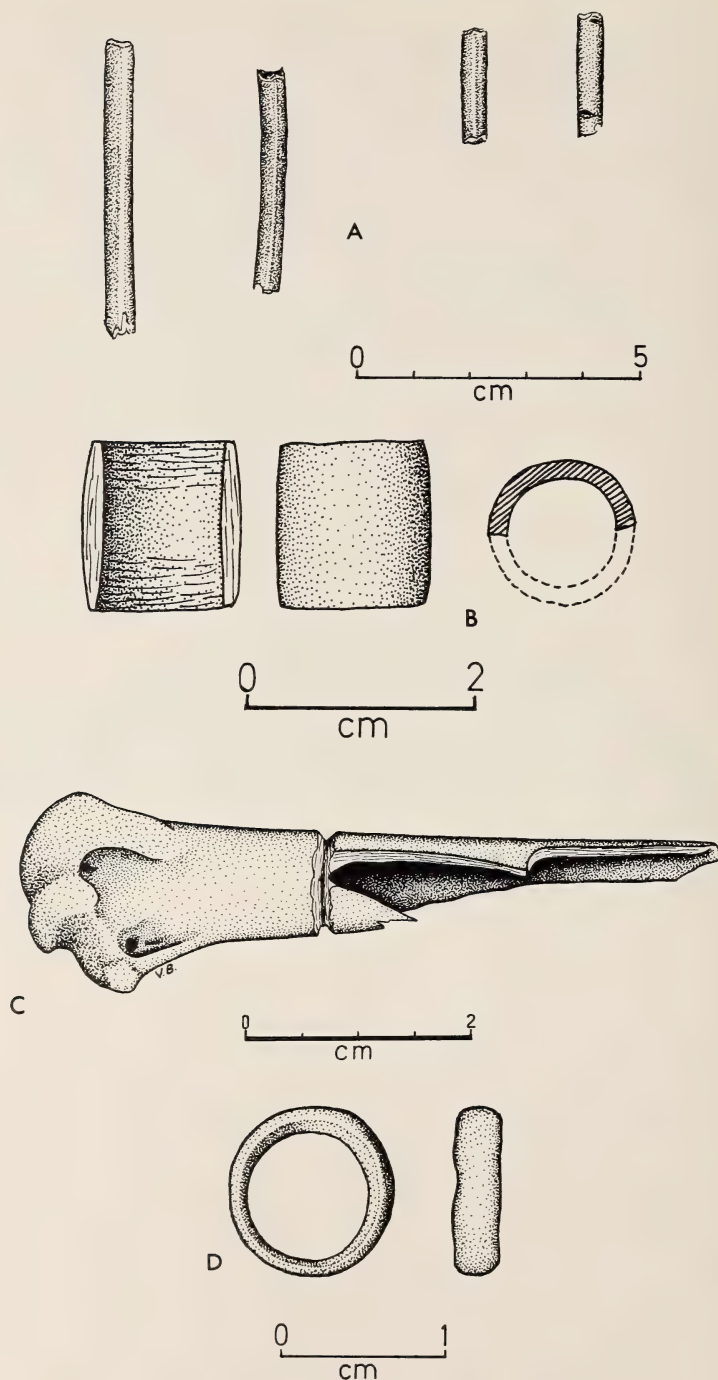


Fig. 18. Bone ornaments. A. Bird bone tubes, SAM-AA2691 layer 12. B. Polished tube, SAM-AA2093 layer 12. C. Snapped tube showing ring grooving, SAM-AA2087 layer 12. D. Bone ring, SAM-AA1186 layer 12.

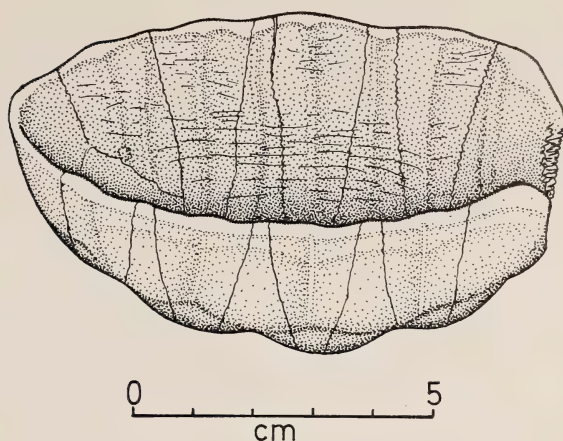


Fig. 19. Tortoise carapace bowl, SAM-AA209 layer 2.

### *Conclusions*

That the sample of bone artefacts from Die Kelders gives a reasonably full picture of the bone tool technology of the Cape coast dwellers is supported by the evidence from less well-provenanced samples in museum collections. Bone fish gorges, which have been found at other coastal sites, e.g. Robberg (R. R. Inskeep pers. comm.), Elands Bay (C. Poggenpoel & J. E. Parkington pers. comm.) and Byneskranskop (Schweitzer & Wilson 1978) are, however, absent from the sample. Although published evidence is at present largely lacking, it seems that the use of fish gorges was not known in the time covered by the DK 1 deposits, those found at the other sites occurring in deposits dated to about 10000 years B.P. The general level of functional interpretation of the bone artefacts does not pose difficulty and categories such as projectile points and tortoise bowls have good ethnographic analogies. It is more difficult to ascribe specific functions to categories such as the piercing artefacts (e.g. awls and needle awls) and spatulae. Certainly awls occur in very high frequencies at coastal sites and this is suggestive of their use in some activity related to occupation of the coastal zone. One possibility suggested above is maintenance and manufacture of clothing, but direct evidence, such as the remains of skin garments, is lacking.

### SHELL ARTEFACTS

#### *Introduction*

The use of shells as ornaments is a fairly universal practice and may be expected at coastal sites such as Die Kelders where suitable shells could be readily collected. Not only have isolated shell ornaments been recovered at

sites on the Cape coast, but also shell beads and other ornaments have been found in direct association with prehistoric human burials (Péringuey 1911: 162). Shells were also modified to serve as artefacts (Goodwin 1938a: 216, 1938b: 307–309; Louw 1960: 101–103; Van Noten 1974: 129, fig. 6). With few exceptions the shells used for ornaments and artefacts are not the by-products of shell collecting for food but rather the result of selective collecting aimed specifically at utilization of the shell itself.

### *Description of the shell artefacts in the midden*

The artefactual shell can be discussed under the headings ornaments, containers, and tools.

#### *Ornaments*

##### *1. Perforated shells (Fig. 20)*

The occurrences of perforated shell ornaments are listed in Table 4.

*Conus* spp could not be identified beyond genus level owing to loss of colour and shell wall. 'Cones are predominantly a tropical/semi-tropical group. Three species occur on the cold west coast, the numbers increasing, as in cowries, as one moves up the east coast' (Kensley 1973: 204). It is assumed that the relative scarcity of this genus in the deposit (1,9% of the total for perforated shell, Table 4) reflects the geographical situation of DK 1 near the western limits of its habitat. A noticeable feature of the *Conus* shells recovered from the excavation is that thirty-four of the total of thirty-eight were perforated by means of a filing process which resulted in a clearly defined V-shaped notching in the shell (Fig. 20A). The remaining four shells, which comprise the entire *Conus* sample of layer 12, were all perforated by means of jagged, punched holes (Fig. 20B), the more usual method of perforation in other shells. A detailed layer count of *Conus* shells set out in Table 5 shows them to have been more or less evenly distributed throughout the deposit but with a peak in layer 4. File-perforated *Conus* shells were found at Matjies River in layer D (Louw 1960: 96, fig. 34) and at other southern Cape sites.

*Marginella* are small shells with four characteristic pleats on the columella. That 'the mantle can be reflected over the shell when the animal is extended, and keep the surface polished' (Barnard 1951: 59) would have enhanced the shell's value as an ornament.

*Bullia* are the conical plough shells frequently to be seen 'ploughing' the surface of sandy beaches along the water-line. Their shells comprise some 18 per cent of the total perforated shell assemblage and they are listed in Table 4 as two separate species, both of which are found on sandy beaches close to DK 1. The species have been further subdivided into size categories to determine any size preferences. Small (< 2,0 cm) *B. laevis* appear to have been preferred in the upper layers, while the larger (> 2,5 cm) *B. digitalis* were preferred in layers 7 and 12. The generally low and variable frequencies do not, however, lend themselves to more than mere observation. It should also be borne in mind,

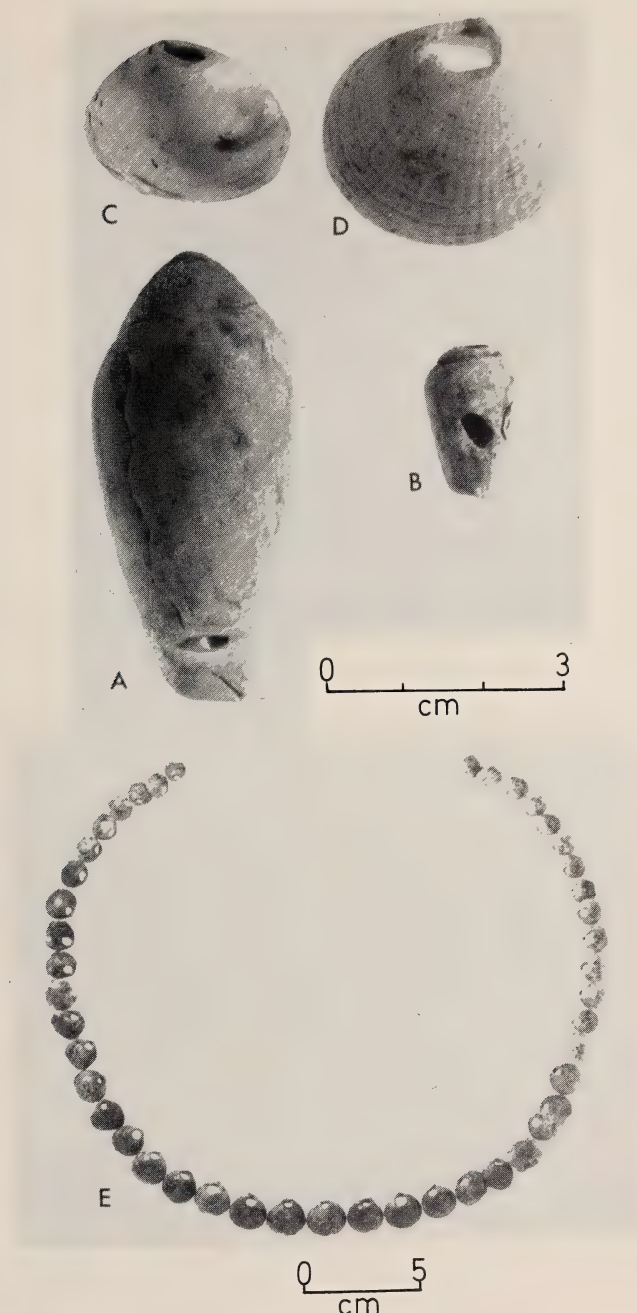


Fig. 20. Perforated shells. A. *Conus* perforated by filing, SAM-AA334 layer 4. B. *Conus* perforated by punching, SAM-AA3161 layer 12. C. *Glycimeris* perforated by filing, SAM-AA124 layer 2. D. *Glycimeris* perforated by punching, SAM-AA206 layer 2. E. *Glycimeris* ochre-stained 'necklace', SAM-AA2437-2514 layer 1.



TABLE 4  
Marine shell: perforated shells.

Layer	1	2	3	4	5	6	7	8	9	10	12	15a	15b	22	22b	Total	% by species of total perforated shells recovered
<i>Conus</i> spp . . . . .	3	1	5	12	1	1	7	2	—	2	4	—	—	—	—	38	1,9
<i>Marginea</i> spp . . . . .	2	6	1	1	—	—	13	—	—	—	2	—	—	—	—	25	1,2
<i>Bullia digitalis</i> < 2,5 cm . . . . .	7	—	1	9	3	1	14	9	1	11	15	—	2	—	—	73	3,6
<i>B. digitalis</i> > 2,5 cm . . . . .	9	4	2	7	1	—	36	5	—	6	29	—	—	—	—	99	4,9
<i>B. laevissima</i> < 2 cm . . . . .	5	13	15	96	18	—	9	1	1	1	6	—	1	—	—	166	8,3
<i>B. laevissima</i> > 2 cm . . . . .	5	—	—	3	—	—	6	1	—	2	9	—	1	1	1	29	1,4
<i>Nassa kraussiana</i> . . . . .	57	38	146	284	172	33	151	53	3	51	120	1	3	—	—	1 112	55,2
<i>Burnupena</i> spp . . . . .	1	2	—	5	1	—	4	1	—	4	3	—	1	—	—	22	1,1
<i>Phalium zeylanica</i> . . . . .	—	2	—	—	—	—	—	—	—	—	2	—	—	—	—	4	0,2
<i>Cypraea</i> spp . . . . .	—	—	—	1	1	—	4	—	—	3	1	—	—	—	—	10	0,5
<i>Natica genuana</i> . . . . .	2	4	—	—	—	—	—	—	—	1	1	—	—	—	—	8	0,4
<i>Tricolia kochii</i> . . . . .	8	9	17	42	30	15	33	3	—	11	4	1	1	—	—	174	8,6
<i>Glycimeris queketti</i> (definite)	10	147	11	6	—	1	10	5	—	1	1	—	1	3	1	197	9,8
Other . . . . .	2	3	2	8	2	6	15	5	—	—	13	—	—	—	—	56	2,8
Layer total . . . . .	111	229	200	474	229	57	302	85	5	93	210	2	10	4	2	2 013	99,9
% by layer of total perforated shells recovered	5,3	11,1	10,0	23,8	11,4	2,9	15,0	4,3	0,25	4,7	10,4	0,05	0,5	0,15	0,05		99,9

TABLE 5  
Marine shell: *Conus*.

Layer	Perforated by filing	Perforated by piercing	Filed but not perforated	Unperforated	Layer total
1 . . . . .	2	1	—	—	3
2 . . . . .	1	—	—	—	1
3 . . . . .	5	—	1	—	6
4 . . . . .	12	—	—	—	12
5 . . . . .	1	—	—	1	2
6 . . . . .	1	—	—	—	1
7 . . . . .	7	—	—	—	7
8 . . . . .	2	—	—	—	2
9 . . . . .	—	—	—	—	—
10 . . . . .	1	1	—	—	2
12 . . . . .	—	4	—	1	5
Class total . . . . .	32	6	1	2	41
Bead total . . . . .					38

as in the case of the *Glycimeris* 'necklace' (see below), that deliberate selection of graded shell sizes would be obscured by the subdivisions made.

*Nassa kraussiana*, a small gastropod which is found mainly from Still Bay to Mozambique (that is, from some 180 km further east than Die Kelders), attains a size of  $6 \times 4.7$  mm (Kensley 1973: 160) and is certainly too small for food. It is abundant in weed-beds that are exposed at low tide on the muddy banks of estuaries (Day 1969: 167). A few species listed under *Nassa* spp belong to species other than *N. kraussiana*. *Nassa* beads are well known from coastal and inland sites along the southern Cape coast, and at Scott's Cave (Deacon & Deacon 1963: 206), Wilton (Deacon, J. 1969: 1972), Melkhoutboom (Deacon, H. J. 1976: 53–54), and Boomplaas (Deacon, H. J. *et al.* 1978: 54), for example, are found in horizons related to occupations dating from the early Holocene onwards. These are numerically the largest component of the perforated shell ornaments at DK 1 (55.2% of the total, Table 4).

*Burnupena* spp belong to the family Buccinidae or whelks. All are either predators or scavengers and form an important unit in the ecology of the intertidal rocky shores, especially around the Cape (Kensley 1973: 152). They are of a size (up to 40 mm) suitable for food, though, unlike their larger counterparts in Europe (*Buccinum undatum*), they have never been commercially exploited in historical times. They are included in Table 4 only where the perforations appear to have been deliberately made. As the bulk of these shells are unperforated, they have been included in Table 20, which details the frequencies of marine shell from the sieved bulk samples.

*Phalium zeylanica* belongs to the family of 'helmet shells'. It has a number of knobs around the shoulder and is strongly built. These gastropods burrow just below the surface of sheltered sands at low-water spring tides (Day 1969:

167). Two of the four shells recovered came from layer 2, the others from layer 12 (Table 4).

The family Cypraeidae or cowries, 'form one of the best known families of molluscs because of their colourful and glossy shells' (Kensley 1973: 100). Cowries are essentially tropical and no species occur on the west coast. Three species occur in False Bay and the number increases as one moves up the coast (Kensley 1973: 100). The *Cypraea* listed in Table 4 cannot be identified further than genus level owing to loss of colour and shell wall.

*Natica genuana* belongs to the family Naticidae or 'necklace shells', a name which is reportedly derived either from the necklace-like ornamentation found in some species, or from the shape of the spawn (Barnard 1951: 104). However, perhaps the reason is their use in necklaces. These shellfish are sand or mud dwellers; like *Bullia* they are predators and it is considered unlikely that they were collected for food.

*Tricolia kochii* is only slightly larger than *Nassa* and, after *Glycimeris*, the next most common gastropod. Maximum length is about 12 mm (Kensley 1973: 52), but the size of specimens at DK 1 are generally a few millimetres below this.

*Glycimeris queketti* is the only member of the family Mytilidae (mussels) found at DK 1 to have been deliberately perforated for stringing. Valves are of various sizes and holes show signs of enlargement by punching or filing. The frequencies given in Table 4 are only for shells in which the perforation could definitely be termed artefactual. Fifty-three valves with apparently natural openings, which may none the less have been used, are included in the contents in Table 6, but are excluded from the grand total of 197 shells with large, punched holes or filed apertures (Fig. 20C-E). Of this total, forty-two valves were found heavily ochre-stained and lying very close together in the deposit in layer 2 (Fig. 20E, *not*, however, as illustrated).

In Table 4 the category 'other' is made up mainly of *Thais* spp, common in the intertidal zone, and *Turbo* spp. These, with a few shells of other genera that complete the total, do not contribute meaningfully to the assemblage as a whole.

## 2. Perforated discs and pendants (Fig. 21)

Round and oval discs made of the nacreous shell of *Turbo sarmaticus* varying in size from  $6 \times 8$  mm to  $10 \times 12$  mm form the main finds in this category (Table 7). In all cases the outside edges were carefully worked. This is shown in Figure 21M-O which also shows the circular groove marks left by the drill used for boring the aperture. The holes were always drilled from the inside of the shell, but in a number of cases were completed by drilling from the outside. The depth of the groove marks indicates that the boring tool must have had a very short, sharp point. Evidence for the use of shell discs in necklaces was recently found at a site near Cape St Francis, eastern Cape (Thackeray & Feast 1974: 92, fig. 1), where twenty-seven similar discs made of *T. sarmaticus* were found round the cervical vertebrae of a midden burial. A tibia from the

TABLE 6  
Marine shell: perforated *Glycimeris*.

Layer	Obviously enlarged aperture	Filed opening	Natural opening (possibly utilized)	Layer total	% of grand total
1 . . . . .	8	2	3	10	5,1
2 . . . . .	143*	4	16	147	74,6
3 . . . . .	9	2	5	11	5,6
4 . . . . .	3	3	3	6	2,8
5 . . . . .	—	—	1	—	—
6 . . . . .	1	—	2	1	0,5
7 . . . . .	7	3	2	10	5,1
8 . . . . .	2	3	2	5	2,5
9 . . . . .	—	—	3	—	—
10 . . . . .	1	—	2	1	0,5
12 . . . . .	1	—	11	1	0,5
15b . . . . .	—	1	—	1	0,5
22 . . . . .	3	—	1	3	1,5
Ashy soil . . . . .	—	1	—	1	0,5
22c . . . . .	—	—	2	—	—
Class total . . . . .	178	19	(53)	Grand total 197	99,9

\* Including 42 ochre-stained shells found associated.

burial has been radiocarbon dated to  $5180 \pm 65$  years B.P. (Pta-1089) (De Villiers 1974: 91).

In addition to small perforated discs (or 'buttons', Fig. 21E-H, J-L), the shell ornaments also include larger pendants which have a more striking appearance. These are also made mainly of *T. sarmaticus* shell and are more common in the lower layers of the deposit (Table 7). They vary in size and shape (Fig. 21B-D, I, M-O) but most are oval with one or two holes drilled close to one end. The largest and possibly most distinctive item is a round pendant made of *Haliotis midae* which has one hole drilled just off centre (Fig. 21A).

### 3. Marine shell beads (Fig. 22A-G)

The simplest manufactured marine shell ornaments at DK 1 are thin, flat nacre beads, bored and rubbed down to an oval or round shape (Fig. 22A-G), which apparently were manufactured in the same way as ostrich egg-shell beads, as described by Goodwin (1938b: 309). There were seventeen such beads distributed throughout the sequence.

### 4. Ostrich egg-shell beads (Fig. 22H-K)

These are common at all Cape Holocene sites and are also found distributed throughout the DK 1 midden sequence (Fig. 22 H-K). Many show ochre staining. The numbers of beads in the sample and egg-shell fragments from



which they could have been made are given in Table 8. The numbers in themselves have reduced significance when it is appreciated that a modern Bushman necklace requires about five ostrich egg-shell beads per centimetre of string length. From this it can be calculated that some 2 000 beads would be required for a typical multi-stranded necklace or about 8 000 beads for an apron. The large numbers of ostrich egg-shell beads at a site such as DK 1 are thus explained.

### *Containers*

Both ostrich egg-shell and marine shell recovered from DK 1 represent material apparently used as containers. The ostrich egg-shell fragments were worked to a concave edge which is thought to have formed part of the original aperture of a water container (Fig. 22L). The use of such containers has been

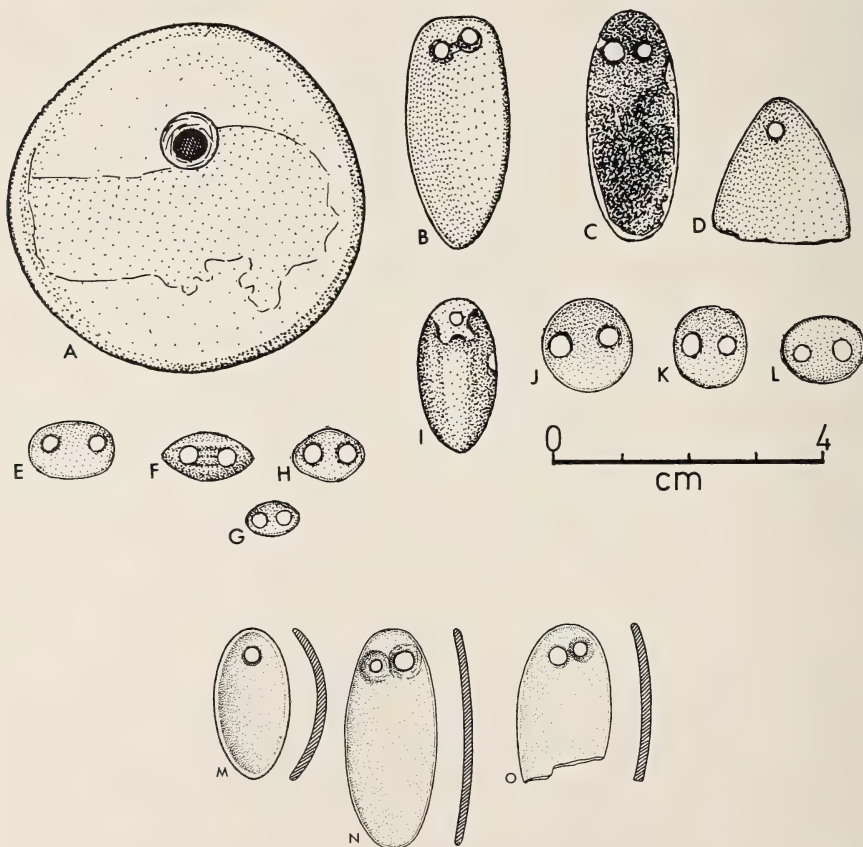


Fig. 21. Shell pendants and 'buttons'. A. SAM-AA2283 layer 12. B. SAM-AA3439 layer 12. C. SAM-AA1206 layer 12. D. SAM-AA287 layer 10. E. SAM-AA3166 layer 10. F-H. Unprovenanced. I. SAM-AA521 layer 5. J. Unprovenanced. K. SAM-AA3144 layer 7. L. SAM-AA1079 layer 7. M. SAM-AA521 layer 5. N. SAM-AA1206 layer 12. O. SAM-AA1306 layer 12.

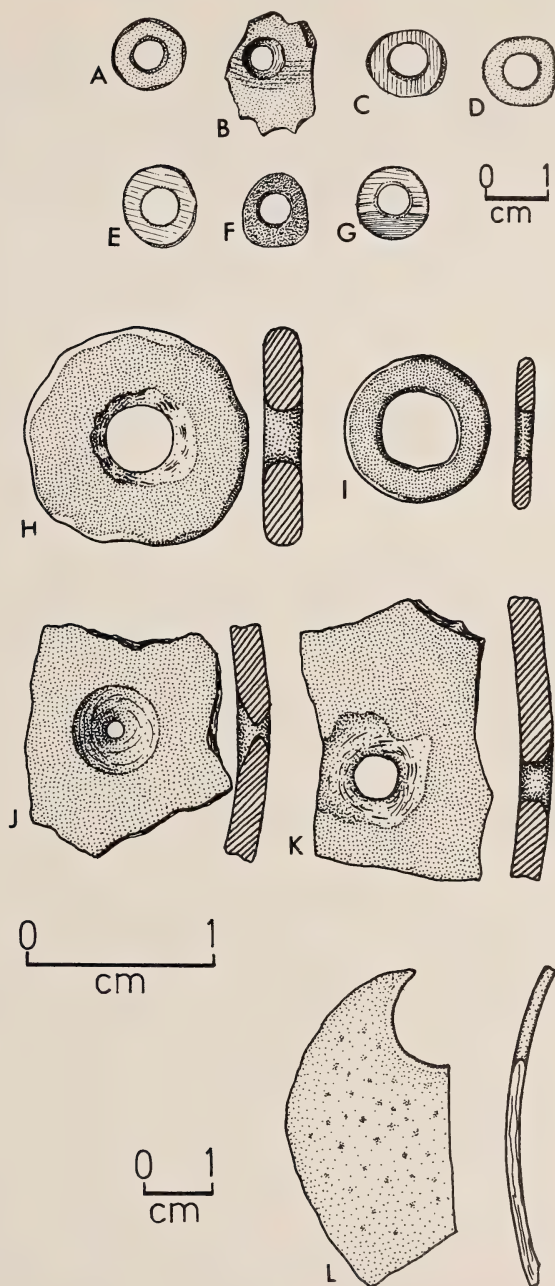


Fig. 22. Shell beads. Marine: A. SAM-AA357 layer 7. B. SAM-AA358 layer 7. C. SAM-AA366 layer 7. D. SAM-AA533 layer 7. E. SAM-AA2585 layer 10. F. SAM-AA678 layer 12. G. SAM-AA1688 layer 12. Ostrich egg-shell: H. SAM-AA477 layer 7. I. SAM-AA2139 layer 12. J. SAM-AA232 layer 2. K. SAM-AA1572 layer 12. L. SAM-AA1664 layer 12.

TABLE 7  
Marine shell: pendants.

Layer	Double perforated 'button' pendants	Single holed pendants	Double holed pendants	Unperforated pendants	Broken bored pieces	Large round pendant	Layer total
1 . . . . .	2	—	—	—	—	—	2
2 . . . . .	2	2	—	1	1	—	6
3 . . . . .	—	—	—	—	—	—	—
4 . . . . .	6	—	—	—	—	—	6
5 . . . . .	1	1	—	—	—	—	2
6 . . . . .	—	—	—	—	—	—	—
7 . . . . .	7	1	1	—	3	—	12
8 . . . . .	2	1	1	1	1	—	6
9 . . . . .	—	—	—	1	—	—	1
10 . . . . .	5	2	—	—	1	—	8
12 . . . . .	—	—	3	—	—	1	4
Class total . . .	25	7	5	3	6	1	47

well attested in numerous ethnographic and archaeological reports (see Goodwin 1938*b*: 252). Frequencies of marine shells which are considered to have served as ochre receptacles are listed in Table 9. With few exceptions these comprise fairly large ( $8 \times 5,5$  cm to  $10,5 \times 11$  cm) *Patella argenvillei*. All show heavy ochre staining on the inside but no other modification. Some ten to fifteen unbroken *Haliotis midae* shells were found to contain semi-articulated fish bones. Although this association may be fortuitous in a midden where there are numerous fish remains, it is worth noting. Examination of the *H. midae* shells in the laboratory showed the edge of one to have been ground smooth

TABLE 8  
Ostrich egg-shell: beads and fragments.

Layer	Beads		Fragments	
	Finished	Unfinished	No.	Mass (g)
1 . . . . .	90	—	41	33,6
2 . . . . .	228	5	46	36,2
3 . . . . .	129	—	35	33,9
4 . . . . .	203	—	86	102,7
5 . . . . .	91	—	75	78,8
6 . . . . .	33	—	12	10,6
7 . . . . .	388	2	196	188,2
8 . . . . .	61	1	52	67,2
9 . . . . .	70	1	68	68,9
10 . . . . .	250	—	175	215,0
12 . . . . .	2 850	16	1 176	1 043,7
15 . . . . .	22	—	13	30,8
20 . . . . .	1	—	—	—
22 . . . . .	7	—	78	150,6
Total . . . . .	4 423	25	2 053	2 060,2

TABLE 9  
Marine shell: ochre containers.

Layer	<i>Patella argenvillei</i>	<i>Patella compressa</i>	<i>Choromytilus/Perna</i>	Total
2 . . . .	1	—	—	1
10 . . . .	3	—	4	7
12 . . . .	8*	1	—	9
22 . . . .	1	—	—	1
Total . . . .	13	1	4	18

\* Includes one broken container.

and round and thus clearly to have been modified as an artefact. These large shellfish are edible and the shells themselves, despite their branchial holes, have obvious potential for use as containers.

### *Shell tools*

Shell implements in the form of edge-trimmed *Donax serra* valves and *Choromytilus meridionalis* 'crescents' were first observed and recognized by Goodwin at Klipkop cave (Goodwin 1938a: 216) and at Oakhurst (Goodwin 1938b: 307–309). Louw (1960: 11, fig. 44) recovered similar 'crescents' at Matjies River and Van Noten (1974: 129, fig. 6) reported finding a *Donax* 'scraper' at Gordon's Bay.

#### 1. *Donax serra* 'scrapers' (Fig. 23)

In contrast to the 'one or two' trimmed *Donax* pieces found in each layer by Goodwin at Oakhurst, the Die Kelders sample yielded close to 1 600 of these. The frequency distribution is given in Table 10. All specimens show steep working (or damage) on all or part of their edges. The retouch appears to have been deliberate and resulted in the formation of scraper-like edges. By far the greatest number of these artefacts occurs in layer 12 (about 50%). The function of these implements is not known, but it is apparent that *Donax* shells were collected primarily for use as artefacts because unworked valves are rare. This is reflected in the low frequencies shown in Table 20, which lists shellfish food frequencies from individual layers. Unmodified *Donax* shells occur in only five out of a total of forty-one samples and are limited to layers 10 and 12.

#### 2. *Shell 'crescents'* (Fig. 24)

Delicate 'crescents' made of *Choromytilus meridionalis* were more difficult to identify. These thin and brittle artefacts are difficult to distinguish from naturally broken mussel shells, and it was questioned whether they formed a valid category of implements. Microscopic study of the arc edge has since revealed that at least some such 'crescents' may have been modified by grinding (as opposed to flaking as is the case with stone crescents) (Fig. 24G). They do



TABLE 10  
Marine shell: *Donax*, utilized or worked.

Layer	Frequency	% of grand total
1 . . . . .	50	3,2
2 . . . . .	19	1,2
3 . . . . .	24	1,5
4 . . . . .	76	4,8
5 . . . . .	51	3,2
6 . . . . .	20	1,3
7 . . . . .	289	18,3
8 . . . . .	33	2,1
9 . . . . .	—	—
10 . . . . .	104	6,6
12 . . . . .	797	50,6
15a . . . . .	10	0,64
15b . . . . .	4	0,25
20 . . . . .	5	0,3
22 . . . . .	47	3,0
22b . . . . .	36	2,3
22c . . . . .	11	0,7
Grand total . . . . .	1 576	100,0

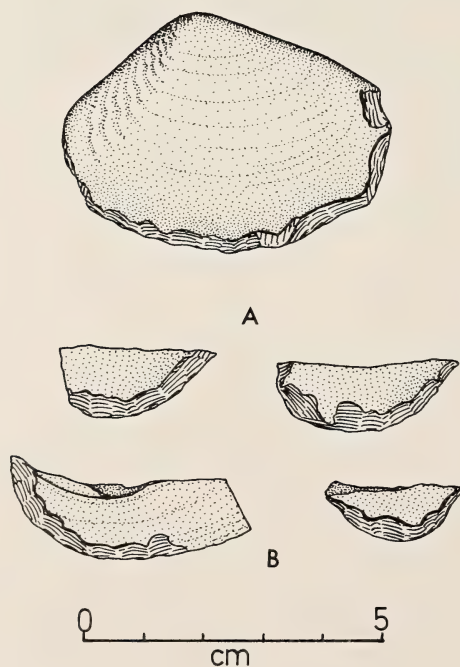


Fig. 23. Edge-trimmed *Donax serra* valves.  
A. SAM-AA1239 layer 12. B. SAM-AA1113  
layer 12.

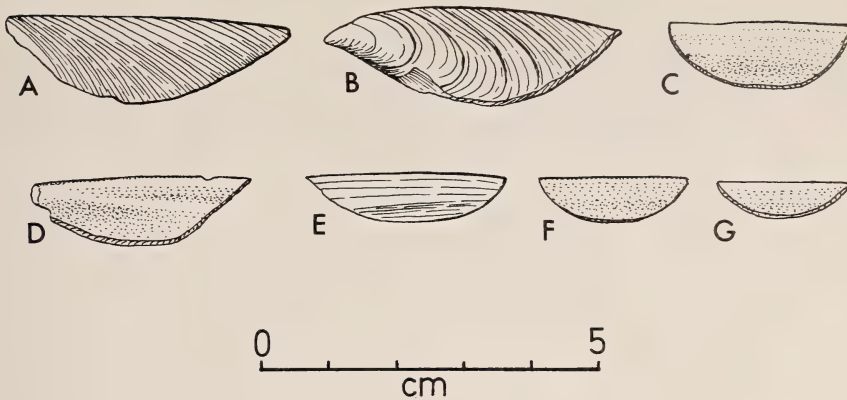


Fig. 24. *Choromytilus* 'crescents'. A. SAM-AA3469 layer 2. B. SAM-AA3470 layer 2. C. SAM-AA3471 layer 12. D. SAM-AA3472 layer 2. E. SAM-AA3473 layer 12. F. SAM-AA3474 layer 1. G. SAM-AA1075 layer 12.

not, however, form a significant part of the assemblage and counts were not made.

#### *Discussion of the shell artefacts*

The variety of shells used as ornaments is striking and it is also clear that the human behaviour implicit in the selection of specific species and the mode of working these is strongly patterned. Notable here is the occurrence of *Nassa* beads in quantity at this site, as at sites along the whole southern Cape, and the habit of filing out notches in *Conus* shells, which is also widespread. At present, the site's shell ornaments would seem only to indicate similarities with sites in the areas to the east, but the Die Kelders data will become more meaningful when there are fuller reports on shell finds from sites on the west and east coasts as well as inland; their distribution in both time and space could be informative of aspects of cultural stability and continuity, and possibly also trade. It seems well established in this study that shells were useful for purposes other than ornaments although shell 'crescents' remain a somewhat dubious entity.

#### POTTERY

##### *Introduction*

The pottery from Die Kelders was found throughout the top member, except layers 6 and 8. The sample is relatively large and is noteworthy for the unexpected range of shapes and the high quality of most of the material. A total of 1 118 sherds recovered by excavation was reduced to 810 after joining as many sherds as possible in an attempt to reconstruct the original vessel forms. The remains of at least 46 vessels are represented, with 7 sufficiently complete for their reconstructed forms to be drawn, and another 2 to be partly reconstructed.

TABLE 11  
Pottery: analysis of sherds.

Layer	Total excavated	Total after joining	Total adiablastic	Total diagnostic					Mean thickness (mm) (excluding rims) $\bar{x} \pm \text{s.e.}$
				Reconstructed vessels	Individual sherds not included in reconstructed vessels				
					rim sherds	spouts	bases	decorated	
1	3	3	3	—	—	—	—	—	5,2 ± 0,7
2	118	84	79	1	2	1	—	1	5,9 ± 0,5
3	9	9	9	—	—	—	—	—	6,3 ± 0,5
4	5	5	5	—	—	—	—	—	4,6 ± 0,3
5	3	3	3	—	—	—	—	—	8,2 ± 0,1
6	—	—	—	—	—	—	—	—	—
7	20	20	18	—	2	—	—	—	6,4 ± 0,4
8	—	—	—	—	—	—	—	—	—
9	4	4	4	—	—	—	—	—	5,5 ± 0,5
10	10	10	8	—	2	—	—	—	5,7 ± 0,3
12(T)	946	672	623	6	41	—	2	—	5,5 ± 0,1
12(s)	217	145	133	1	10	—	—	1	6,9 ± 0,2
12(q)	729	527	490	5	31	—	—	1	5,0 ± 0,1

Note. 12(T) = details for layer 12 as a unit.

12(s) = details for layer 12 sherds with shale/siltstone inclusions only.

12(q) = details for layer 12 sherds with quartz (and other) inclusions.

The analysis of the pottery is given in three tables. Table 11 analyses the layer occurrence and type of the sherds and gives the range of sherd thickness. Table 12 analyses rim sherd form, and Table 13 is a descriptive analysis of the reconstructed vessel from the main pottery-bearing layers, 12 and 2.

TABLE 12  
Pottery: analysis of rim sherds.

Layer	2	7	10	12s	12q
Type					
Plain-rounded . . . . .	1				1
Plain-squared . . . . .					5
Tapered-rounded . . . . .					1
Tapered-squared . . . . .					1
Externally ridged-rounded . . . . .	3	2	1	10	11
Externally ridged-squared . . . . .					4
Everted-rounded . . . . .					4
Everted-squared . . . . .					1
Inverted-rounded . . . . .					1
Inverted-squared . . . . .					1
Half-rounded internally . . . . .					5
Half-rounded externally . . . . .					1

Note. Rim sherds clearly part of the same pot are counted as one, even if not joined, except in the case of the layer 2 and layer 12s externally ridged sherds, although these are probably parts of the same pots.

TABLE 13  
Pottery: analysis of reconstructed vessels.

Layer	No.	Figs.	Form	Height mm	Rim diam. mm	Body diam. mm	Mean thickness mm	Approx. capacity litres	Measurement ratios	
									H/D	D/R
12 .	1	25A, 26	pot	195	170	220	5	3,4	0,89	1,29
	2	25B, 27	pot	150	170	190	4	1,8	0,79	1,12
	3	25C, 28	pot	145	110	130	5	1,0	1,11	1,18
	4	25D	bowl	—	220	225	5	—	—	1,02
	5	25E	bowl	—	215	235	6	—	—	1,09
	6	25F	bowl	130	205	215	6	2,4	0,60	1,05
	7	25G	pot	155	170	200	6	2,7	0,77	1,18
	8	25H	bowl	140	220	230	7	2,8	0,61	1,04
2 .	1	30-32	pot	220	70	195	5	2,9	1,13	2,78

- Note. 1. All dimensions are calculated from the outside of the pot, and to the nearest 5 mm.  
 2. Dimensions are calculated from the graphic reconstructions where actual measurement has not been possible.  
 3. Volumetry based on calculation formulae in Ericson & Stickel (1973). Calculations are based on external dimensions less mean thickness and allow 10 mm empty from the rim, or to the rim trimming groove in nos 12.1 and 12.2, and in no. 2.1 to the centre of the higher boss (175 mm from base).  
 4. The mean thickness of no. 12.8 was calculated by measurements taken at seventeen points (approx. 10 mm apart) along the drawn profile of the bowl.  
 5. Ratio: H = vessel height, D = maximum body diameter, R = rim diameter.



The materials and methods used in the manufacture of pottery have been discussed by Rudner (1968: 442–447) and the technical aspects of the DK 1 pottery are dealt with on a general level only, since the complex methods of physical analysis are considered to be beyond the scope of this report. Analysis is thus confined to selected attributes such as sherd frequencies, thickness, rim and vessel morphology. Of interest is the inclusion in Table 13 of the calculated approximate capacities of the reconstructed vessels. Vessel capacities are considered an important attribute, as analyses based simply on shape and similar physical characteristics tend to overlook the function of the vessels as artefacts related to specific human needs.

### *Discussion of the pottery samples by layers*

Sherd frequencies quoted in this discussion are based on the total(s) of sherds after joining (Table 11), each set of joined sherds being counted as one sherd.

Vessel forms are defined as follows:

a *pot* has a height not less than 0,75 of its maximum body diameter, and usually also has a rim diameter less than its maximum body diameter;

a *bowl* has a height less than 0,75 of its maximum body diameter, and its rim diameter should be equal to or only slightly (0,1) less than its maximum body diameter.

The definitive proportions used here differ somewhat from those used by Rudner (1968: 444–445), who defined the proportions for a bag-shaped pot as height : maximum body diameter 0,90 or more, and maximum body diameter : rim diameter 1,39 or less. His proportions for a bowl are height : maximum body diameter 0,89 or less, and maximum body diameter : rim 1,39 or less (as for bag-shaped pots).

Table 13 shows that the height : maximum body diameter (H/D) ratio is 0,89 or less for all the layer 12 vessels except no. 3 (Fig. 25C), suggesting that these should be classified as bowls in terms of Rudner's typology. This is at variance with the visual evidence which shows at least two vessels, nos 1 and 2 in layer 12 (Fig. 25A–B), that would commonly be described as pots rather than bowls.

### *Layer 12 (Figs 25–29)*

85 per cent of the total of the sherds from the site came from this layer, and these gave the greatest number of diagnostic pieces, including six of the seven reconstructed vessels. In Table 11 the material from this layer has been subdivided into sherds with shale/siltstone non-plastic inclusions ('temper'), designated 12(s), and sherds with quartz and other inclusions, designated 12(q).

#### *1. Sherds with shale/siltstone inclusions*

These form a visually distinct group. Apart from the difference in 'temper' they are mostly of light-brown clay which has apparently been lightly fired.

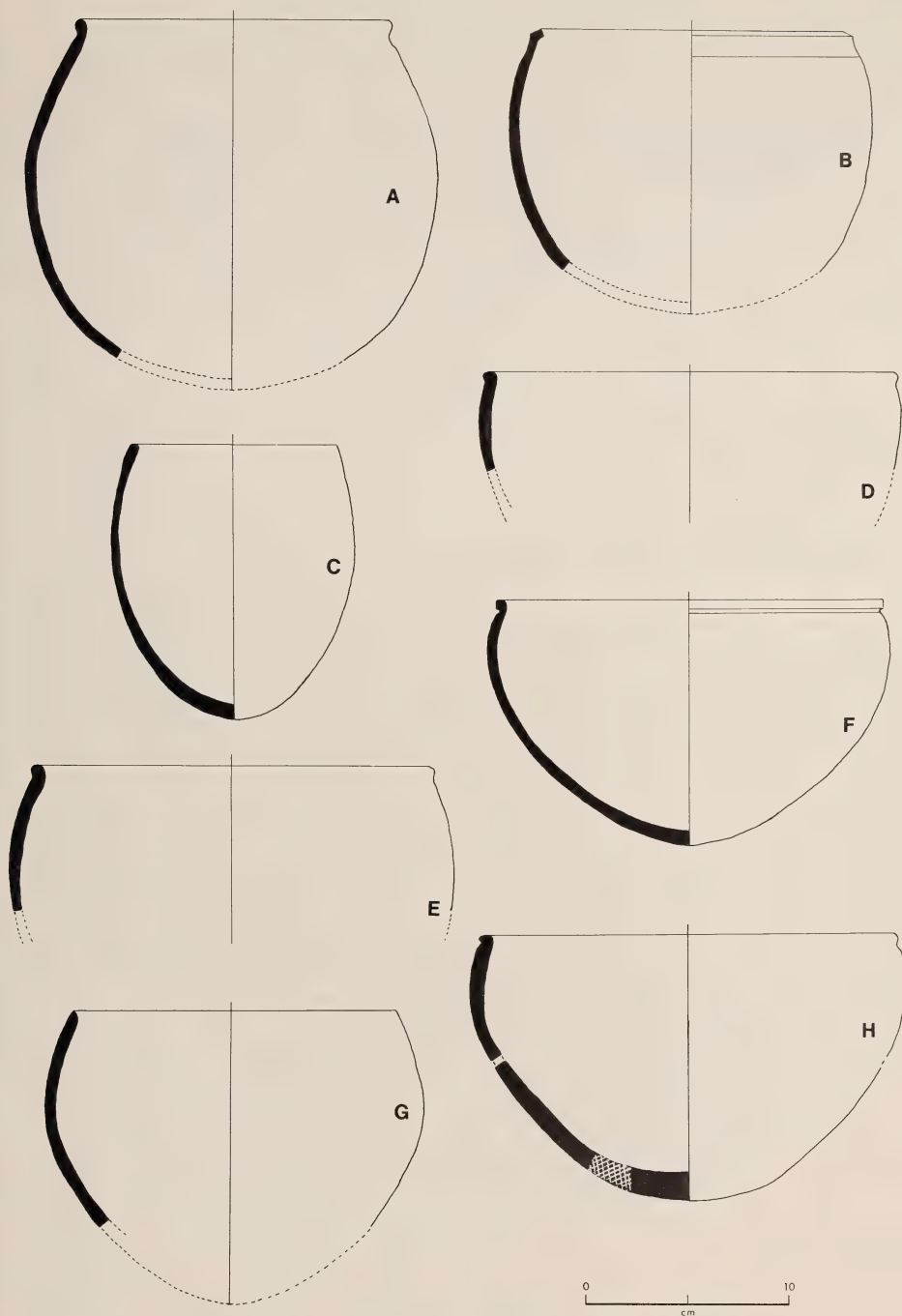


Fig. 25. A. Layer 12 pot no. 1, SAM-AA1040 (see also Fig. 26). B. Layer 12 pot no. 2, SAM-AA690 (see also Fig. 27). C. Layer 12 pot no. 3, SAM-AA757 (see also Fig. 28). D. Layer 12 pot no. 4, SAM-AA1361. E. Layer 12 pot no. 5, SAM-AA1218. F. Layer 12 pot no. 6, SAM-AA1350. G. Layer 12 pot no. 7, SAM-AA1049. H. Layer 12 pot no. 8, SAM-AA1250.

Their range of thickness is greater than that of the other sherds in the rest of the deposit, reaching a maximum of 14,5 mm. In general they give the appearance of being less well finished than the other sherds in this layer. It has been possible to join a number of sherds into larger composite fragments. These consist of ten sets of rim sherds, a section of a body and portions of a base. Although it has not been possible to join these major pieces, a possible reconstruction of the shape is shown in Figure 25H. This was arrived at by matching the curve and thickness of the middle section with the known diameter of the rim. The cross-hatched section represents an area of overlap of the middle and base sherds.

## *2. Sherds with quartz and other inclusions*

This material is generally of fine quality, well finished and apparently well fired. Reconstructions undertaken during 1974-5 have resulted in the partial rebuilding of seven small vessels shown in Figures 25A-G and 26-29 which show a marked divergence from the norms of 'Strandloper' (or Hottentot)



Fig. 26. Layer 12 pot no. 1.





Fig. 27. Layer 12 pot no. 2.



pottery as suggested by Rudner (1968: 456–459): 'Strandloper vessels are generally necked (84,5%), but there are also some bag-shaped ones (13,5%) and a few bowls (2,2%). The base of the Strandloper pot is generally pointed (81,6%). Globular bases are uncommon (8,4%). . . . Strandloper pottery is almost always well fired, the exceptions being mainly bowls. . . .' There are, however, two aspects of conformity that are interesting and perhaps important in terms of geographic distribution: the maximum occurrence of undecorated ware is found in the Agulhas area and on the south-western coast (Rudner 1968: 463); wall thicknesses of less than 6 mm comprise 34,1 per cent and are found mainly on the west coast and from the south coast to the East London area (Rudner 1968: 459).

The pot shown in Figures 25B and 27 shows considerable sophistication in its concave neck and inverted square rim as well as in its thickness, which ranges from 3 to 5 mm. The pot shown in Figures 25C and 28 is to within a few millimetres a perfect truncated ellipse. It is also worth noting that the thinnest sherds, measuring 2,5 mm, were found in layer 12. 80 per cent of the sherds have a high to medium density of fine to medium (up to 2 mm) angular quartz inclusions. However, the occurrence of chunks of up to 7 mm suggests that at least some of the inclusions are natural inclusions in the clay. Ten sherds have inclusions other than, or including, quartz, but these components have not been identified.

Figure 29 shows a reconstructed base which, together with the evidence of the pots shown in Figures 25A–B, F–G and 26–27, tends to support the indication that the pots in layer 12 have bases which are more rounded than pointed. A sherd from this layer has not been included with the diagnostic material in Table 11 as its function or position cannot be ascertained. It contains part of a conical perforation, the outer surface of which continues into the remnants of a broken-off protrusion. As the hole was made before firing and known repair holes do not have protrusions (Rudner 1968: 460), it is thought that the hole may have been designed for the passing through of a string or thong for carrying.

The bulk of the layer's quartz sherds are black or dark-brown, but there are four varying from grey-brown to buff, and one with an off-white outer surface on a brick-red core, probably re-fired after breakage.

Most of the material is well finished and finely wiped or burnished on the outer surface, though the pot shown in Figure 26 has a somewhat granular surface. This effect may have been deliberate as the inner surface is well smoothed. There is no indication of ochre-staining, nor of the carbonized fatty accretions observed on other coastal pottery (Rudner 1968: 598) and on sherds in layer 2.

### *Layers 10–3*

The quantity of sherds from these layers, especially of diagnostic material, is disappointingly small. Layers 8 and 6 yielded no pottery at all and what has

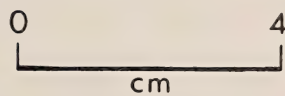


Fig. 28. Layer 12 pot no. 3.

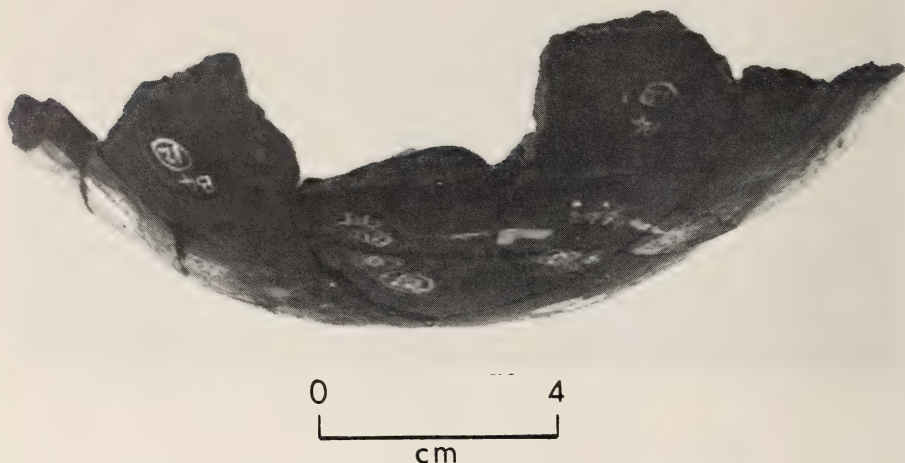


Fig. 29. Layer 12 globular pot base, SAM-AA1909.

come from the other layers allows for little else to be said about it than that it appears to conform to the norms for the site and for coastal pottery in general. Nine sherds from layers 10 and 7 could be joined to sherds from layer 12. This indicates that more material from these two layers may have been derived from the earlier occupation, though this cannot be further substantiated. The majority of the sherds in layers 10–3 contained inclusions similar to those in the quartz-containing sherds of layer 12, and also included burnished pieces.

#### *Layer 2 (Figs 30–34)*

This layer provided 10,4 per cent of the total of joined sherds and included the upper portions and base of a fine spouted pot shown in Figures 30–32. This pot has a comb-stamped rim and extruded bosses on the shoulder decorated with a roughly oval design of radial linear impressions, which is highly reminiscent of *Patella* (limpet) shells (Figs 30, 31B, 32). The outer surface appears to have been stained with red-brown ochre before firing, and is well burnished. Eleven of the diagnostic sherds, as well as the two rim sherds also appear to belong to this pot. The asymmetrical form of the pot is best seen in Figures 30 and 32, which show the side away from the spout as having a greater curvature than the side with the spout. Although most of the spout is missing, reconstruction of the shape was made possible by the finding, in 1979, of a large sherd with a complete spout. This sherd, which had eroded out of the upper levels to the west of the excavated area, also has an extruded boss with *Patella*-like decoration as well as comb-stamping on the spout rim. These features, together with the evidence of another spout recovered from a section collapse, point either to a common tradition or to the work of the same potter. The sherd with

the boss and spout has, however, decoration in the form of ten dragged bands on the spout neck above the boss and two bands of impressed dots on both sides of the spout, whereas the layer 2 pot has only decorated bosses and rim. Spouted pots represent only 6,4 per cent of the material studied by Rudner (1968: 456), who also reports that their maximum occurrence (15,9%) is on the south-western Cape coast.

The remainder of the sherds are from quite another class of pot and include the spout fragment shown in Figure 33. The sherds in this group appear to have come from larger, less well-made vessels than the reconstructed pot. They are for the most part black, unburnished and partly coated with carbonized material, which can be seen on the illustrated spout fragment (Fig. 33). Scrapings of the carbonized material were submitted to the Department of Biochemistry of the University of Cape Town for analysis and possible identi-

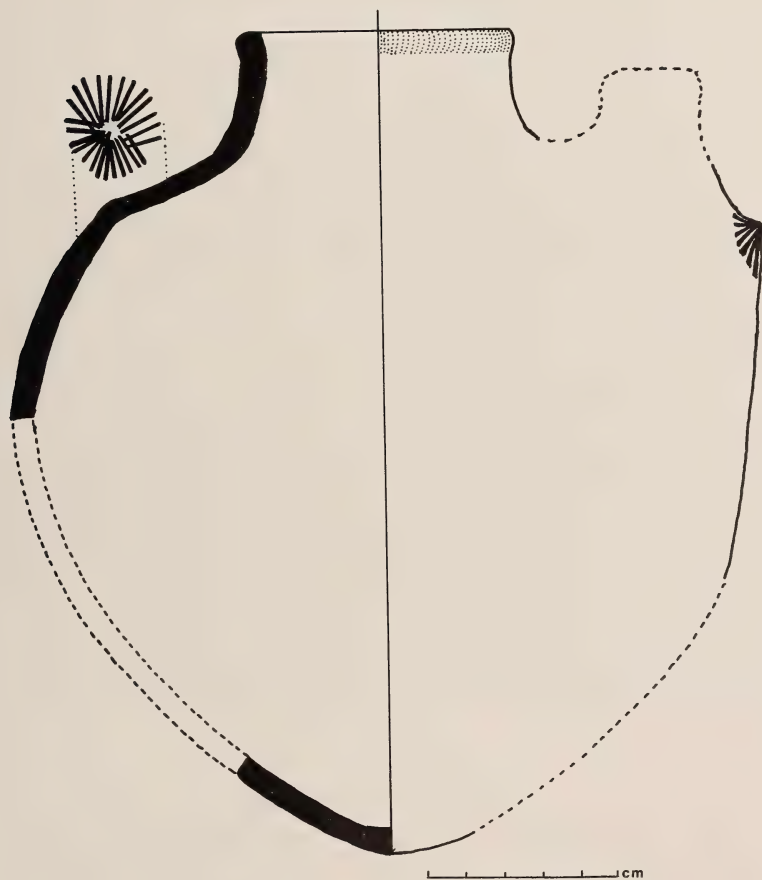


Fig. 30. Layer 2 pot no. 1. SAM-AA154. Reconstruction.



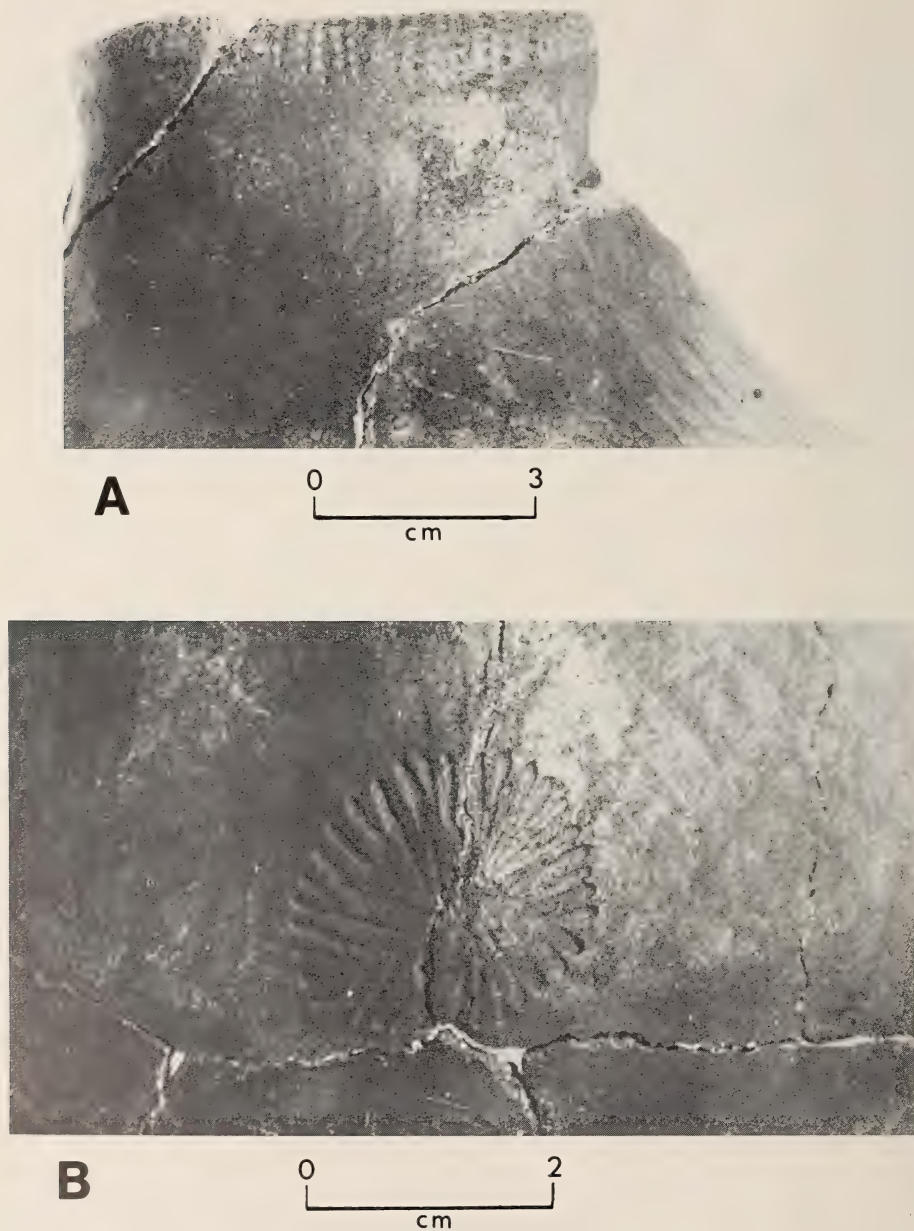


Fig. 31. Layer 2 pot no. 1. A. Detail of neck. B. Detail of decorated boss.



Fig. 32. Layer 2 pot no. 1. Restored upper section of pot.

fication. In its report (letter dated 13 April 1970) the Department states that 'the contents of the pot as well as the material adhering to the outside also contain protein. The proportion of the amino acid is reasonably well in agreement with that of contemporary protein. On the basis of this it is fairly safe to say that the charred residues removed from the inside and outside of the pot represent food material . . . because of the relative high content of lysine the samples are possibly of animal origin.' The above finds would be in keeping with the presence of domestic stock in layer 2 (see below) whose milk and/or meat may well have contributed to the contents of the pots.

75 per cent of the sherds have a high to medium density of fine to medium angular quartz grain inclusions. The similarity between these inclusions and those from layer 12 suggests continuity in the use of the same, possibly local, clay sources. The layer also contains an unusually decorated sherd, shown in Figure 34. As may be seen, the decorations consist of two sets of overlapping



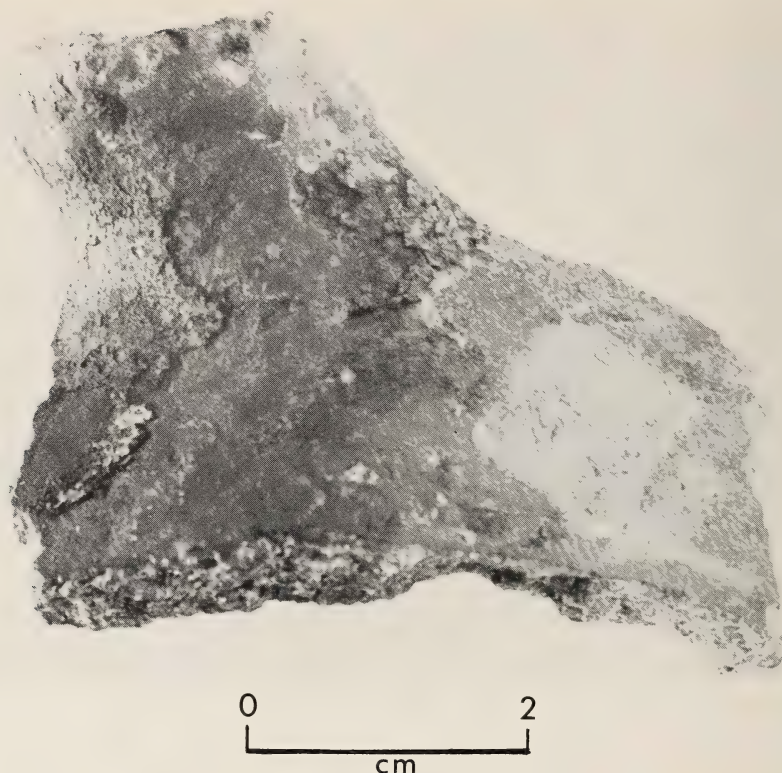


Fig. 33. Layer 2, spout fragment with carbonized material adhering, SAM-AA2950.

impressed bands, one in the centre of the sherd and one near the edge. These are unlike the comb-stamping on the rim of the reconstructed pot from this layer (Fig. 31A) and replication tests carried out to ascertain the nature of the tool used showed that the ventral edge of a *Donax serra* shell produces impressions identical to those on the sherd. This provides another example of uses to which marine shell could be put. It is difficult to assign the sherd to any known pot or other sherds in the assemblage for, although in appearance it is similar to the spouted pot, it does not appear to belong to it for two reasons. Firstly, since the pot is almost complete in circumference in its upper part, this would represent only isolated decoration on one part of the circumference; secondly for the lower part of the pot to be decorated would be a most unusual circumstance (Rudner 1968: 457). On the other hand, there are too many bands for the impression to have been accidental rather than deliberate, and it is therefore concluded that a second brown pot, similar in some respects to the reconstructed pot, is also represented. The suggested minimum number of pots represented by the sherds in this layer is five.

*Layer 1*

As with the sherds from layers 10–3, there is little that can be said about the three sherds from this layer, except that they appear to conform to the norms for the site and for coastal pottery.

*Discussion of the potsherds*

The analysis of the DK 1 pottery throws new light on early local pottery and poses a number of interesting questions about its distribution and manufacture. The main concentration of potsherds in layer 12, and the wealth of other associated cultural and food remains, are in keeping with the interpretation of this layer as an occupation surface. Also of importance is layer 2 with its well-made spouted pot, and in this case the pottery is associated with the remains of at least eighteen sheep (Table 27), suggesting the sampling of another important occupation phase. The pottery from layer 12 demonstrates that skilfully made vessels were being used along this coast some 2 000 years ago and its introduction to the site was clearly at a time when the craft was well developed. The paucity of material from layers 10–3 leaves unanswered the question of whether the form of the layer 2 pot (which, with its decorated neck and bosses, spout and pointed base, is a more or less typical Hottentot, or 'Strandloper', pot), evolved directly from the globular pots and bowls of

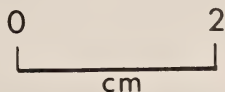


Fig. 34. Layer 2, decorated sherd, SAM-AA3475.





Fig. 35. Mastic-impregnated sand artefact from layer 2, SAM-AA3330.

layer 12, or whether this later form was introduced from elsewhere during the period between the two occupations. Nevertheless, it is evident from the bulk of the layer 12 material that pot-making was not a technological invention at DK 1: the origin of this tradition is a problem that cannot be answered by material from this site alone.

#### MISCELLANEOUS

An unusual piece of mastic-impregnated fine sand was found in layer 2. Its shape suggests that it might have served to unite four minor barbs to the main shaft of an arrow (Fig. 35). There is no ethnographical or historical record of such arrows being used by Bushmen or Hottentots.

#### LITHIC ARTEFACTS

##### *Introduction*

Goodwin (1938a: 219) described the stone artefacts from Klipkop as '... broken in use rather than to any plan. They consist of chipped and split sea pebbles.' This also describes aptly the lithic assemblage at DK 1, though it will be seen that it also includes some backed and formal microliths. In some sense this was an advantage as it encouraged looking at the stone tool component less as a culture marker and more as a source of information on adaptive behaviour.

### *Raw materials*

Frequencies of raw materials (Table 14) are, in diminishing order: quartzite (49,5% of the artefact total), quartz (41,7%), limestone (6,7%), silcrete (1,5%), and chalcedony (0,6%).

#### *Quartzite*

This occurs in the form of:

pebbles, cobbles and boulders (sized according to Pettijohn 1957: 20), which are abundantly available from the beach a few metres below the site;

earlier made (M.S.A.) stone implements. These are recognizable by their differing raw material, which is generally a fine-grained Bokkeveld quartzite, by the use of a prepared platform technique, and sometimes by their formal shape. Their acquisition would have required the least amount of effort, entailing only picking up the artefacts where they eroded out of their exposed surfaces, either at the cave's drip-line or from near-by limestone cliff exposures.

#### *Quartz*

This occurs as veins in the T.M.S. where it sometimes attains its crystal form. It is also sometimes found in the form of cobbles.

#### *Limestone*

This is also readily available, both in the form of beach cobbles and from the cliffs lining the local coast.

#### *Silcrete*

This occurs both in near-by outcrops and in the form of cobbles.

#### *Chalcedony*

A local source for this rare constituent of the assemblage has not yet been found, but it is found elsewhere in the south-western Cape, usually in the form of small pebbles in river-beds or alluvial gravels.

#### *Red ochre*

This occurs in the T.M.S. and was present throughout the deposit in sizes ranging from about 3 mm maximum dimension to larger pieces of about 40 mm. The numerous fragments, some of which showed marks of abrasion, were not counted.

### *Artefact description and analysis*

The typology used in the description and analysis of the artefactual stone from DK 1 follows, in general outline, that used by J. Deacon (1978) for her analysis of the material from the Nelson Bay Cave, southern Cape. Three main categories are discussed: waste, utilized pieces, and formal tools.

TABLE 14  
Stone: raw material by artefact categories, classes and layers.

Layer	1	2	3	4	5	6	7	8	9	10	12	Yellow sand	20	22	22b	Layer total	% of class total	% of site total for individual raw material
Waste																		
Chips: total																		
Qe		3	1	43	6	1	55	17	1	3	445	1				576	3.6	0.6
Q		1		1	4		8	1			5					21	93.4	19.2
L		2		38	2	1	47	16	1	3	428					538	1.4	1.8
S			1	4							4					8	7	1.2
C											6					2	0.3	5.1
Chunks: total																		
Qe	54	65	59	189	52	17	423	97	42	305	661	29	1	4	1	1999	44.4	26.7
Q	40	45	23	39	32	6	202	25	21	204	229	21				888	50.0	35.7
L	12	16	33	149	17	10	194	69	20	81	386	7	1	4		999	5.2	23.1
S	2	4	3	1	3	1	27	2		19	42					104	4	4.0
C								1	1	1	2	1				4	0.2	10.3
Cores: total																		
Qe	1	4		2			8			3	40			2	1	61	31.1	0.6
Q	1	1		1			4			1	10			1		19	42.6	0.9
L		3					2			2	17			1		26	19.7	2.7
S											9					12	3.3	2.0
C											2					2	3.3	5.1
Untrimmed flakes: total	95	75	62	206	80	31	586	114	20	274	1728	58		4	11	3344	52.5	52.9
Qe	67	56	38	80	33	21	375	48	13	202	767	44		4	8	1756	(22M)	
Q	12	8	21	109	35	10	121	61	4	37	(16M)				1	181	35.3	42.2
L	16	11	1	14	10		84	5	3	32	753	7			3	318	9.5	70.5
S			1	3			5			3	55	6				73	2.2	72.3
C			1		2		1				12					16	10.5	41.0
Utilized																		
Trimmed flakes: total																		
Qe		2					2			10	16	3			6	39	84.6	1.0
S							(2M)			10	12	3			(6M)	33	(30M)	
C		2								(10M)	(9M)					5	12.8	4.9
Heavy edge-damaged pieces: total		(2M)									3					(2M)	1	2.6
Qe											1					18		
L				2			3	3		4	6					17	94.4	0.5
S											5					1	5.5	0.2
Single and multi-flaked cobbles: total																		
Qe	1	11	4	32	1	2	61	11	1	53	63					240	96.7	7.0
L	1	9	4	30	1	2	61	11	1	53	59					232	3	1.2
Q		1									1					3	5	0.1
L		1		1						13	20					56	2.1	1.1
Lower grindstones: total																		
Qe		1		7		1	12	2		12	20					55	98.2	1.7
L										1						1	1.8	0.2

TABLE 14 (cont.)

Layer	1	2	3	4	5	6	7	8	9	10	12	Yellow sand	20	22	22b	Layer total	% of class total	% of site total for individual raw material
Rubbers: total	—	3	7	19	—	13	2	—	18	22	—	—	3	—	—	87	100,0	2,6
Qe	—	3	7	19	—	13	2	—	18	22	—	—	—	—	—	87	100,0	2,6
Combination tools: total	—	—	1	7	1	—	11	1	18	20	21	—	3	—	—	62	100,0	1,9
Qe	—	—	1	7	1	—	11	1	18	20	21	—	—	—	—	62	100,0	1,9
Hammerstones: total	1	7	3	12	2	—	14	4	—	16	18	—	—	—	2	79	98,7	2,3
Qe	—	7B	3B	12B	2B	—	4A 10B	3A 3B	—	7A 9B	6A 12B	—	—	—	2A	78 (20A 58B)	—	—
L	1B	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1B	1,3	0,2
Milled edge pebbles: total	—	1	—	1	—	—	—	—	—	—	—	—	—	—	—	2	100,0	0,1
Qe	—	1	—	1	—	—	—	—	—	—	—	—	—	—	—	2	100,0	0,1
Ochre-stained pebbles and cobbles: total	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Qe	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Anvils: total	—	7	2	12	—	—	16	—	—	12	17	—	—	—	—	66	100,2	2,0
Qe	—	7	2	12	—	—	16	—	—	12	17	—	—	—	—	66	100,2	2,0
L	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	1	100,0	0,2
Grooved stones: total	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	100,0	0,2
Qe	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	100,0	0,2
Utilized quartz crystals: total	—	—	—	1	—	—	—	2	—	6	6	—	—	—	—	15	100,0	0,5
Qe	—	—	—	1	—	—	—	2	—	6	6	—	—	—	—	15	100,0	0,5
Formal tools	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Scrapers: total	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	6	33,3	0,1
Qe	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	6	33,3	0,1
S	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2	33,3	2,0
C	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2	33,3	5,1
Backed tools: total	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1. Segments: total	1	—	—	—	1	—	3	4	2	—	24	—	—	—	—	36	100,0	0,3
Qe	1	—	—	—	1	—	3	4	2	—	24	—	—	—	—	36	100,0	0,3
S	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	3,4	0,7
C	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	19	65,5	4,9
2. Borers: total	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	5	17,2	10,2
Qe	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	5	17,2	10,2
S	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	4	13,8	—
C	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	3,4	—
3. Other: total	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	100,0	0,03
Qe	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	100,0	0,03
S	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	6	50,0	0,1
C	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	3	50,0	7,7
Miscellaneous retouch: total	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	20	100,0	0,03
Qe	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	20	100,0	0,03
S	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	11	55,0	0,4
C	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	3	15,0	3,0
Layer total	154	179	139	534	143	65	1 196	256	86	741	3 087	94	4	10	21	6 709	25,0	12,8
Sample total	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

Note. 1. Qe = quartzite, Q = quartz, L = limestone, S = silcrete, C = chalcodony.  
 2. Numbers in parenthesis followed by M indicate the number of M.S.A. pieces.  
 3. These are included in the artefact class totals.  
 4. Hammerstones: A = pebbles, B = cobbles.  
 5. The percentages in the last two columns are based on the site totals for individual classes (e.g. chips, chunks, etc.), and individual raw materials in all the artefact classes.  
 (These totals are not shown separately in this table.)



*Waste*

This category comprises chips, chunks, cores and untrimmed flakes and accounts for some 89 per cent (5 980) of the total number of stone artefacts at the site (Table 15).

*Chips* are pieces of irregular form, less than 3 mm maximum dimension, lacking bulbs of percussion but considered to be artefactual. These form some 10 per cent of the waste category (Table 15). They consist almost entirely of quartz (93,4%, Table 14) and reflect the brittle nature of this raw material which tends to shatter when struck.

*Chunks* differ from chips in size, being greater than 3 mm maximum dimension. These constitute one-third of the total waste category (Table 15) and consist largely of quartzite (44,4%) and quartz (50,0%) (Table 14).

*Cores* are pieces which show a pattern of working consistent with the systematic removal of flakes. The total sample was too small to warrant division into sub-classes. In the case of coarse-grained quartzite and quartz, flake scars were frequently impossible to identify. This is particularly true of many broken pieces of quartz which did not have percussion marks indicating points of

TABLE 15  
Stone: categories and classes of artefacts (site totals).

Category	Totals	Percentages	
		Category	Site
<i>Waste: total</i>	5 980		89,1
Chips	576	9,6	8,6
Chunks	1 999	33,4	29,8
Cores	61	1,0	0,9
Untrimmed flakes	3 344	55,9	49,8
<i>Utilized: total</i>	667		9,9
Trimmed flakes	39	5,8	0,6
Heavy edge-damaged pieces	18	2,7	0,3
Single and multi-flaked cobbles	240	36,0	3,6
Lower grindstones	56	8,4	0,8
Rubbers	87	13,0	1,3
Combination tools	62	9,3	0,9
Hammerstones	79	11,8	1,2
Milled edge pebbles	2	0,3	0,03
Ochre stained pebbles and cobbles	66	10,0	1,0
Anvils	1	0,1	0,01
Grooved stones	2	0,3	0,03
Utilized quartz crystals	15	2,2	0,2
<i>Formal tools: total</i>	62		1,0
Scrapers	6	9,7	0,1
Backed tools			
Segments	29	46,8	0,4
Borers	1	1,6	0,01
Other	6	9,7	0,1
Miscellaneous retouch	20	32,2	0,3
Total	6 709		

impact. As a result quartz cores may be under-represented in Table 15 as suggested by their low number (61), which is in contrast to the large number of untrimmed flakes. This may be taken to indicate the limits imposed by adhering to the definition of cores as set out above.

*Untrimmed flakes* are those with no visible damage on the laterals that can be ascribed to usage or trimming (Deacon, H. J. 1969: 155). These constitute the largest single class of artefact at the site and their number (3 344) amounts to more than half the total waste category (Table 15). Most are irregular in shape and 41 per cent are primary flakes with cortex still present (Table 16), and more than half (52,5%) are made of quartzite (Fig. 36, Table 14). In classifying untrimmed flakes as artefactual waste, this discussion follows accepted prac-

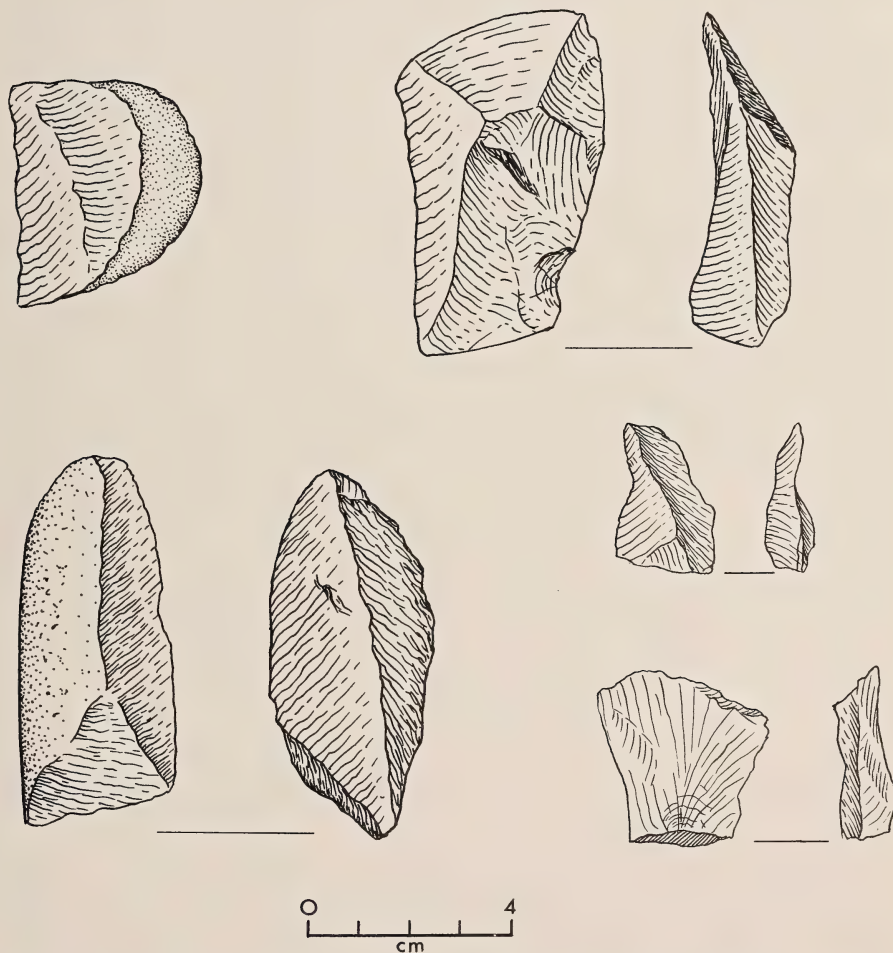


Fig. 36. Untrimmed stone flakes, all quartzite except bottom left which is of limestone, layer 4.

tice (e.g. Deacon, J. 1978: 91, table 1). DK 1, however, has a low frequency of formal tools (Table 15), and such a classification may therefore mask the actual purpose of flake manufacture at this and other coastal sites which, especially in the case of quartzite, might have been intended to produce flakes suitable for use on soft materials, which would have ensured the retention of a sharp edge for some time. Supporting evidence for this contention comes from a report on an expedition which came into contact with a stone-using hunter-gatherer group in the northern part of South West Africa whose use of simple, unretouched flakes showed these to be effective tools for skinning and cutting up antelopes (MacCalman & Grobbelaar 1965: 23).

Of the 1 756 quartzite flakes, 22 were made by the prepared platform technique and are therefore related to the earlier, Upper Pleistocene (M.S.A.), deposits. These have been included with the untrimmed flakes in Tables 14 and 17, their frequencies, followed by an M, in brackets. It was not possible to determine whether these implements had been used again by the cave's later inhabitants as an absence of patination does not allow for any estimation of possible time difference between the original flaking and any subsequent re-use. That the greatest number of these flakes (16) occurs in layer 12 may have been due to a larger number being exposed when the first group of Holocene people came to occupy the cave.

TABLE 16  
Stone: flakes with cortex: frequency analysis by raw material classes and layers.

Layer	1	2	3	4	5	6	7	8	9	10	12
Total of flakes in layer (T)	95	73	62	206	79	31	586	114	20	272	1 712
<i>Quartzite</i>											
Total of flakes (t <sub>1</sub> )	67	54	38	80	32	21	375	48	13	200	751
% T	70,5	74,0	61,3	38,8	40,5	67,7	64,0	42,1	65,0	73,5	43,9
Flakes with cortex	38	38	32	63	22	13	252	37	6	146	531
% t <sub>1</sub>	56,7	70,4	84,2	78,7	68,7	61,9	67,2	77,1	46,1	73,0	70,7
<i>Quartz</i>											
Total of flakes (t <sub>2</sub> )	12	8	21	109	35	10	121	61	4	37	753
% T	12,6	10,9	33,9	52,9	44,3	32,3	20,6	53,5	20,0	13,6	44,0
Flakes with cortex	—	—	4	6	2	—	2	8	—	5	15
% t <sub>2</sub>	—	—	19,0	5,5	5,7	—	1,6	1,3	—	13,5	2,0
<i>Limestone</i>											
Total of flakes (t <sub>3</sub> )	16	11	1	14	10	—	84	5	3	32	141
% T	16,8	15,1	1,6	6,8	12,7	—	14,3	4,4	15,0	11,8	8,2
Flakes with cortex	6	8	1	3	5	—	43	—	1	19	64
% t <sub>3</sub>	37,5	72,7	100,0	21,4	50,0	—	51,2	—	33,3	59,4	45,4
<i>Silcrete</i>											
Total of flakes (t <sub>4</sub> )	—	—	1	3	—	—	5	—	—	3	55
% T	—	—	1,6	1,5	—	—	0,8	—	—	1,1	3,2
Flakes with cortex	—	—	1	—	—	—	—	—	—	—	2
% t <sub>4</sub>	—	—	100,0	—	—	—	—	—	—	—	3,6
<i>Chalcedony</i>											
Total of flakes (t <sub>5</sub> )	—	—	1	—	2	—	1	—	—	—	12
% T	—	—	1,6	—	2,5	—	0,2	—	—	—	0,7
Flakes with cortex	—	—	1	—	—	—	—	—	—	—	—
% t <sub>5</sub>	—	—	100,0	—	—	—	—	—	—	—	—

Note. 1. M.S.A. flakes are not included (see Table 14).

2. Layers yellow sand, 22, 22b do not contain flakes with cortex.

3. The 7 trimmed flakes in layer 12 (Table 14) are all without cortex.

*Utilized pieces*

This is the next to largest category of stone artefacts and consists of a variety of forms which are discussed below, and for which frequencies are given in Tables 14, 15 and 17.

Included in this category is the small mastic-mounted quartz flake found in layer 12 (Fig. 37). The flake has a small (approx. 0,5 mm) bevel across most of its 'working edge', giving it a chisel edge, of which about half shows chipping indicative of utilization. There is no modification of the shape of the flake in the exposed area, and this lends support to the contention mentioned above, that the inclusion of untrimmed flakes in the 'waste' category may mask the actual purpose of flake manufacture.

The mastic, which contains small quartz grains, has been smoothly moulded round the flake, and its lower edge indicates that it was originally attached to some other object, possibly a haft of wood or bone. The cutting back of V-shaped notches into the mastic on both sides of the artefact is problematic: one would expect this to weaken the binding effect of the mastic and it seems to have served no functional purpose, since only the edge of the flake appears to have been used.

*Trimmed flakes* differ from untrimmed flakes in that one or more of their edges is reduced by utilization. Tables 14 and 17 show that of the 39 artefacts in this class only 7, from layer 12, were manufactured by the late Holocene occupants of the site, the remaining 32 being of earlier, Upper Pleistocene (M.S.A.) manufacture. Trimmed flakes are, therefore, not an important element of the stone artefacts at the site after layer 12.

*Heavy edge-damaged pieces* are cobbles usually retaining a substantial part of their original shape but modified by the removal of flakes due to utilization at right angles to their flattened surface. This results in a roughly straight, flaked edge (Fig. 38A-B).

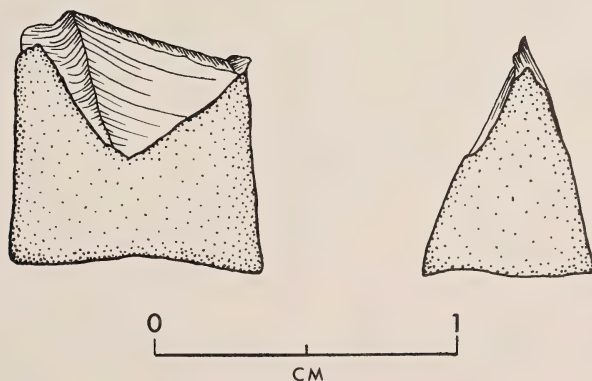


Fig. 37. Mastic-embedded quartz artefact from layer 12, SAM-AA1264.



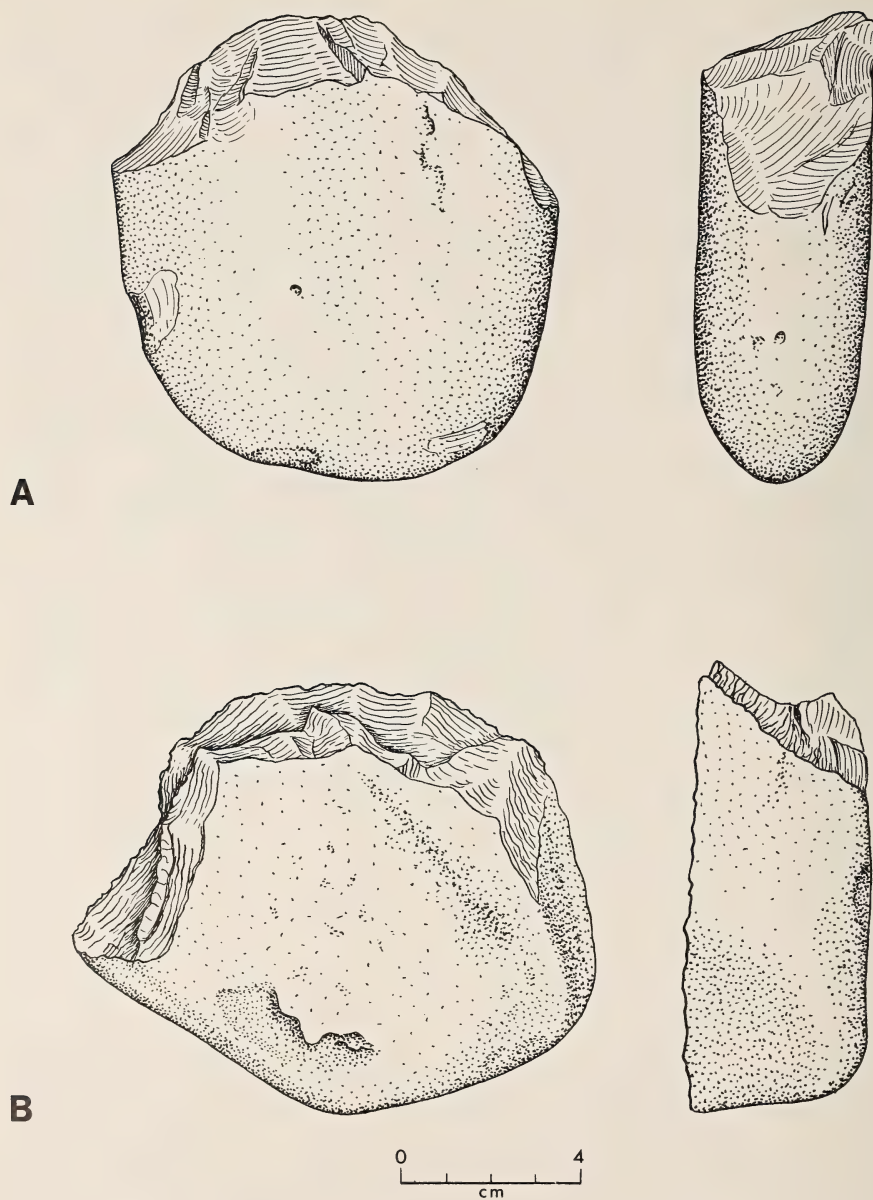


Fig. 38. Heavy edge-damaged pieces from layer 12. A. Limestone. B. Quartzite.

Only eighteen of these artefacts were found at the site. They were distributed fairly evenly through the lower levels up to and including layer 7. After that only two were found, in layer 4 (Table 17). Little is known about the use of such implements which have also been found in the excavated deposits from Nelson Bay Cave (Deacon, J. 1978: 91-92) and the small DK 1 sample is not considered to contribute any new information.

*Single and multi-flaked cobbles* show signs of utilization resulting in the removal of one or more flakes (Fig. 39). These stones, which are almost exclusively of quartzite (96,7%, Table 14), though not showing systematic removal of flakes seem to augment recognizable cores as a major source of untrimmed flakes. By adding multi-flaked cobbles to cores, the previous low ratio of cores to flakes, ranging from 1 : 19 in layer 2 to 1 : 103 in layer 4, is raised to 1 : 7 for layer 2 and 1 : 8 for layer 4. This does not, however, preclude the use of single-flaked cobbles and occasional lower grindstones for flake production, which would further raise the ratio. The use of flaked cobbles is, therefore, regarded as being in keeping with the informal nature of the stone industry at DK 1 which is characterized by the use of any suitable stone to supply required flakes.

*Lower grindstones* are flat-surfaced, partly rounded stones varying in size from 11 × 22 cm to 28 × 50 cm. They bear smoothed concave surfaces or grooves as a result of deliberate and repeated use of the stone for grinding.

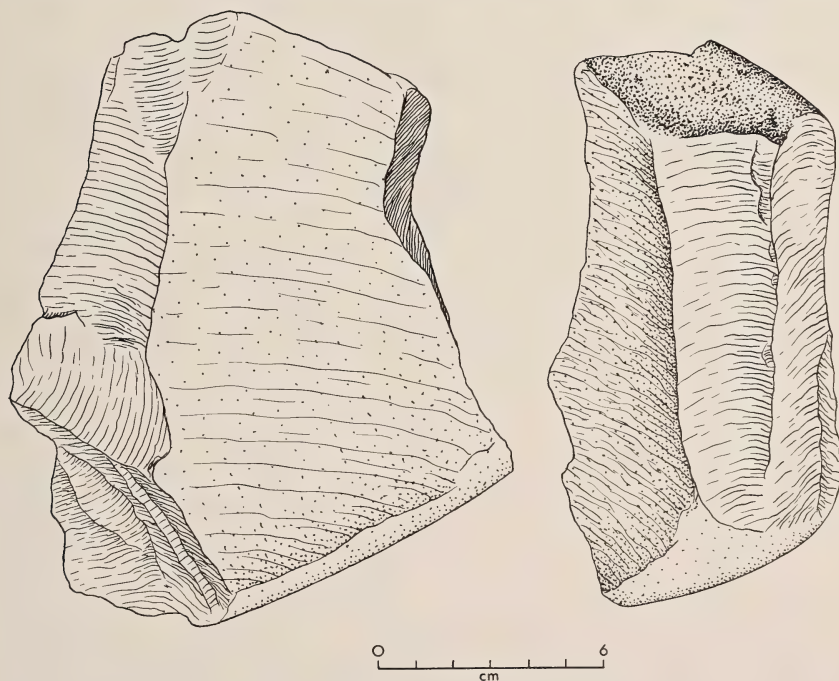


Fig. 39. Multi-flaked cobble, quartzite, layer 7.

TABLE 17  
Stone: categories and classes of artefacts by layers.

Layer	1	2	3	4	5	6	7	8	9	10	12	Yellow sand	20	22	22b	Class total
<i>Waste:</i>																
Chips . . . . .	—	1,7	0,7	8,0	4,2	1,9	4,5	6,6	1,5	0,4	14,3	1,0	—	—	—	8,6
	35,1	36,3	42,4	35,4	36,4	32,7	35,0	37,7	61,8	41,3	21,3	30,5	100,0	30,8	4,8	576
Chunks . . . . .	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	29,8
	54	65	59	189	52	17	423	97	42	305	661	29	1	4	1	1 999
Cores . . . . .	0,6	2,2	—	0,4	—	—	0,7	—	—	—	1,3	—	—	15,4	4,8	0,9
	61,7	41,9	44,6	38,6	55,9	59,6	48,5	44,3	29,4	37,1	55,6	61,0	—	2	1	61
Untrimmed flakes . . . . .	95	75	62	206	80	31	586	114	20	274	1 728	58	—	30,8	52,4	49,8
<i>Utilized:</i>																
Trimmed flakes . . . . .	(2M)	1,1	—	—	—	—	0,2	—	—	(2M)	(16M)	—	—	—	11	3 344
	—	2	—	—	—	—	(2M)	—	—	10	(10M)	3	—	—	28,6	0,6
	—	(2M)	—	—	—	—	—	—	—	—	(9M)	(3M)	—	—	6	39
Heavy edge-damaged pieces . . . . .	—	—	—	0,4	—	—	0,2	1,2	—	0,5	0,2	—	—	—	—	0,3
	—	—	—	2	—	—	3	3	—	4	6	—	—	—	—	18
Single and multi-flaked cobbles . . . . .	0,6	6,1	2,9	6,0	0,7	3,8	5,0	4,3	1,5	7,2	2,0	—	—	—	—	3,6
	1	11	4	32	1	2	61	11	1	53	63	—	—	—	—	240
Lower grindstones . . . . .	—	0,6	—	1,3	—	1,9	1,0	0,8	—	1,8	0,6	—	—	—	—	0,8
	—	1	—	7	—	1	12	2	—	13	20	—	—	—	—	56
	—	—	—	—	—	(broken)	—	(broken)	—	—	—	—	—	—	—	—
Rubbers . . . . .	—	1,7	5,0	3,5	—	—	1,1	0,8	—	2,4	0,7	—	—	23,1	—	1,3
	—	3	7	19	—	—	13	2	—	18	22	—	—	3	—	87
Combination tools . . . . .	—	—	0,7	1,3	0,7	—	0,9	0,4	—	2,7	0,7	—	—	—	—	0,9
	—	—	1	7	1	—	11	1	—	20	21	—	—	—	—	62
Hammerstones . . . . .	0,6	3,9	2,2	2,2	1,4	—	1,2	1,6	—	2,2	0,6	—	—	—	9,5	1,2
	1	7	3	12	2	—	14	4	—	16	18	—	—	—	2	79
Milled edge pebbles . . . . .	—	0,6	—	0,2	—	—	—	—	—	—	—	—	—	—	—	0,03
	—	1	—	1	—	—	—	—	—	—	—	—	—	—	—	2
Ochre-stained pebbles and cobbles . . . . .	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Anvils . . . . .	—	3,9	1,4	2,2	—	—	1,3	—	—	1,6	0,5	—	—	—	—	1,0
	—	7	2	12	—	—	16	—	—	12	17	—	—	—	—	66
Grooved stones . . . . .	—	—	—	0,2	—	—	0,1	—	—	0,1	—	—	—	—	—	0,01
	—	—	—	1	—	—	1	—	—	—	—	—	—	—	—	1
Utilized quartz crystals . . . . .	—	—	—	0,2	—	—	—	0,8	—	0,8	0,2	—	—	—	—	0,03
	—	—	—	1	—	—	—	2	—	6	6	—	—	—	—	2
<i>Formal tools:</i>																
Scrapers . . . . .	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	15
	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	—	—	—	—	—	—	—	—	—	—	0,2	1,0	—	—	—	0,1
	—	—	—	—	—	—	—	—	—	—	5	1	—	—	—	6
<i>Backed tools:</i>																
Segments . . . . .	0,6	—	—	—	0,7	—	0,2	1,6	2,9	—	0,5	1,0	—	—	—	0,4
	1	—	—	—	1	—	3	4	2	—	17	1	—	—	—	29
Borers . . . . .	—	—	—	—	—	—	—	—	—	—	0,3	—	—	—	—	0,03
	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Other . . . . .	—	—	—	—	—	—	—	—	—	—	0,2	1,0	—	—	—	1
	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Miscellaneous retouch . . . . .	0,6	—	—	—	—	—	—	—	2,9	—	0,5	1,0	—	—	—	0,1
	1	—	—	—	—	—	—	—	2	—	5	1	—	—	—	6
Layer total . . . . .	2,3	2,7	2,1	7,9	2,1	0,8	18,0	3,8	1,0	11,0	46,3	1,4	0,01	0,2	0,3	20
	154	179	139	534	143	52	1 208	257	68	738	3 107	95	1	13	21	—
Sample total . . . . .																6 709

Note 1. Numbers in parenthesis, followed by M, indicate the number of M.S.A. pieces (included in the class and layer totals).  
2. Percentages for individual classes in each layer are based on layer totals while those for class and layer totals are based on the sample total.

*Rubbers*, or upper grindstones, are smaller stones of a size easily held in the hand and having at least one smoothed facet. They include split and pecked stones where such pecking, though on the grinding surface, has not impaired the overall smoothness. All rubbers and almost all lower grindstones were made of quartzite beach cobbles (Table 14). As such stones often have smooth, flat surfaces as a result of water action, their classification as grinding tools required care. Stones were included in the frequencies shown in Tables 14, 15 and 17 only on the basis of wear sufficient to rule out any doubts as to their use, and the counts may therefore be conservative.

The numerous upper and lower grindstones, most of which were stained with ochre (Table 18), as well as the number of unworked ochre-stained pebbles and cobbles (Tables 14, 17), attest to the important role of ochre in the daily lives of the inhabitants. This is supported by evidence from other sites dated to a similar period. Powdered ochre was also found at the site in shell containers and as a coating on perforated shells, ostrich egg-shell beads and snake vertebrae. Evidence for its cosmetic and/or ritual use is derived from the child burial (Appendix 3), the skeleton of which was partly enveloped in a thin layer of red ochre in addition to its heavily ochre-stained cranium. Most of the ochre staining associated with the lithic artefacts is red and only very rarely yellow. In addition, black staining, apparently not ochreous, was noted on about one-third of the rubbers (Table 18). In a few cases both red and black occurred on individual rubbers. Such dual colouring was more common on the less frequent lower grindstones. The cause of the black colouring still remains a puzzle. Its staining quality suggests a smooth, fatty compound giving rise to a thin film of adhesive pigment rather than a coating of powdery ochre.

*Combination tools* occupy a category intermediate between rubbers and hammerstones. They are rubbers with patches of abrasion and/or small pecked-out hollows which indicate their use for hammering as well as grinding. These are further distinguished from rubbers by the damage not being situated on the grinding surface. They were all made of quartzite cobbles and were found in most layers of the main excavation (Fig. 40, Table 14).

*Hammerstones* are implements which have areas of pitting and bruising

TABLE 18  
Stone: ochre- and black-stained artefacts.

Layer	2	3	4	5	6	7	8	9	10	12	Total
Total of rubbers and combination tools	3	8	26	1	—	24	3	—	38	43	146
Ochre-stained	1	2	9	—	—	15	2	—	20	22	71
Black-stained	1	2	4	—	—	6	—	—	5	5	23
Total stained	2	4	13	—	—	21	2	—	25	27	94
% of layer total	66,6	50,0	50,0	—	—	87,5	66,6	—	65,8	62,8	64,4
Lower grindstones	1	—	7	—	1	12	2	—	13	20	56
Ochre-stained	—	—	7	—	—	6	1	—	4	16	34



indicating their use as hammers. They have been divided into two sub-classes in Table 14: type A—pebbles that are smooth, flattened and oval pieces *c.* 6 cm long, having hammer wear at either or both ends of the major axis (Fig. 41); type B—cobble hammerstones that are of a larger size and have irregular, pitted patches. Both types occurred in layers 6 to 12 but the upper layers contained only the informal (type B) cobble hammerstones.

*Milled-edge pebbles* are round, flattened quartzite pebbles which are pitted round their entire perimeter as a result of hammering. They may be regarded as belonging to the general hammerstone category. Two were found, one in layer 4, the other in layer 2.

*Ochre-stained pebbles and cobbles* show no utilization but are partly or entirely covered in ochre (see rubbers above). They were found to be distributed throughout the sequence (Tables 14 and 17).

*Anvils*: the only anvil found was a large, flat piece of limestone from layer 4 containing a small hammered-out hollow (or dimple) on one surface.

*Grooved stones* are oval and symmetrical stones measuring between 9 and 12 cm along the major axis. Each bears a noticeable groove parallel to its major axis and in the centre of a broad face. Only two such artefacts occurred in the DK 1 sample, in layers 8 and 12.

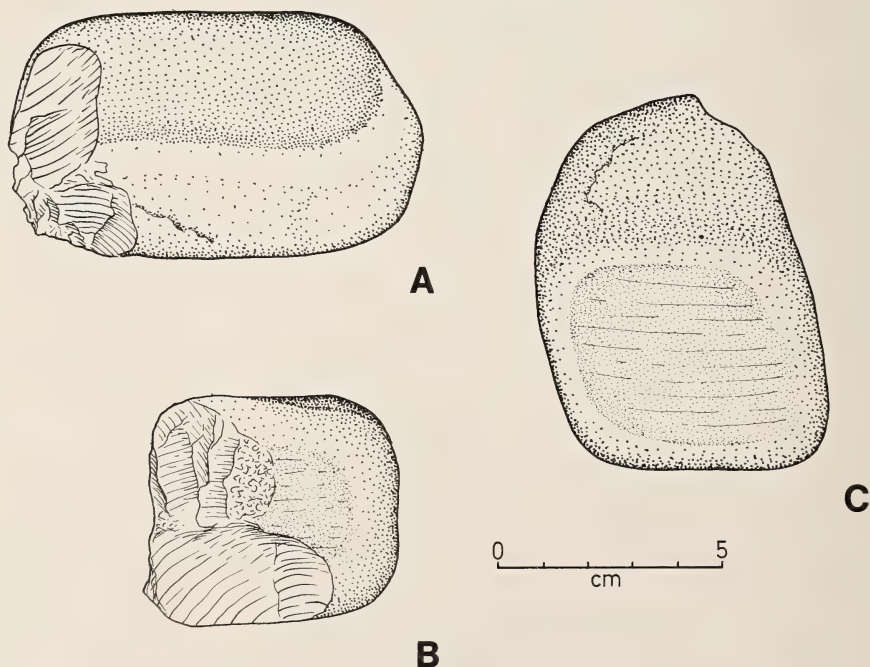


Fig. 40. Combination hammerstone-rubber, quartzite, layer 7. A. Lateral view. B. Ventral view. C. Dorsal view.

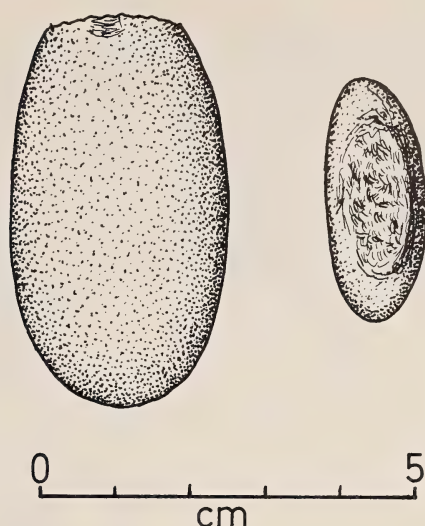


Fig. 41. Hammerstone, quartzite, layer 12.

*Utilized quartz crystals* were found, whole or broken, and with their tips abraded or crushed. This was taken to indicate usage. Most came from the lower layers (Tables 14–15, 17).

#### *Formal tools*

These are defined as pieces that have been deliberately modified to a standard form by secondary flaking, or retouch, but also include pieces which, although lacking formal shape, show deliberate retouch as distinct from utilization.

As is usual in excavated samples, the proportion of formal tools is very low in relation to the total of stone artefacts recovered (Table 15). The two major typological classes represented in the DK 1 sample are scrapers and backed tools, with 'miscellaneous retouch' as a third class incorporating those pieces discussed above which are retouched but lack formal shape.

*Scrapers* are flakes with steep retouch from one side only and usually varying in extent according to the shape of the artefact. Five of the site's six scrapers came from layer 12 and the sixth from the overlying yellow sand layer (Table 17). They are made of the finer raw materials: quartz, silcrete and chalcedony (Table 14), and their shape is generally circular. Positioning of retouch is variable, and the width of the retouched edges ranges between 14 and 20 mm (mean 14,5 mm). Because of their low frequency and variety of shapes, scrapers have not been divided into morphological sub-classes such as side- and end-scrapers, and it is fair to say that it is only the nature of the retouch that holds these tools together as a class (Fig. 42).

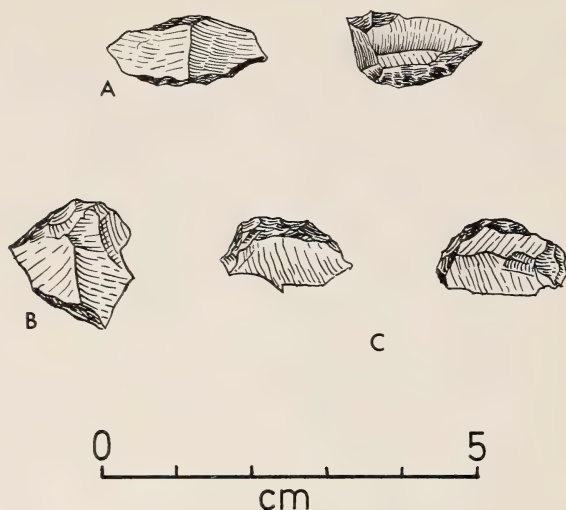


Fig. 42. Scrapers. A. Silcrete.  
B. Quartz. C. Chalcedony.

*Backed tools* are flakes and blades with fine retouch on one lateral, approximately at right angles to the main flake surface and forming a blunted edge generally opposed to a sharp, unretouched edge. Three sub-classes are recognized in the DK 1 assemblage.

1. *Segments*: these are backed along the arc, with the chord remaining unretouched and sharp. Shape ranges from the 'regular' segment shape with a relatively long chord and a short radius (Fig. 43A–E), to pieces that are more triangular (Fig. 43F–G) (see Sampson 1974: 333, fig. 121 nos 1–7). 17 of the 29 segments came from layer 12 alone (Table 14), and of the total 19 are made of quartz (Table 17), which probably accounts for their generally small size, which ranges from 10 to 19 mm. Measurement of segment lengths from other Holocene occurrences in the south-western Cape (e.g. Vensterklipkop and Brakfontein (L. Wadley pers. comm.)) indicates that segments made of quartz are smaller than those made of silcrete or chalcedony. L. Wadley (pers. comm.) has quoted mean lengths of 14,0 mm for quartz segments, and 18,2 mm for silcrete segments from Vensterklipkop.

2. *Borers*: the single borer from the site came from layer 12 and is made of quartz (Table 14). It is a piece in which the backing converges with the unretouched lateral to form a blunt point (Fig. 43H).

3. *Other*: the six remaining backed pieces, all from layer 12, are made equally of quartz and chalcedony (Table 14). They lack formal shape and are included in the general class of backed tools by virtue only of their having backing on one lateral.

*Miscellaneous retouch* covers a range of generally small flakes on which the partial retouch does not justify their inclusion in any of the above categories. The seemingly casual and varying positions of the retouch suggests either that they are incomplete tools, or that they were used for functions which cannot be determined (see H. J. Deacon 1976: 61).

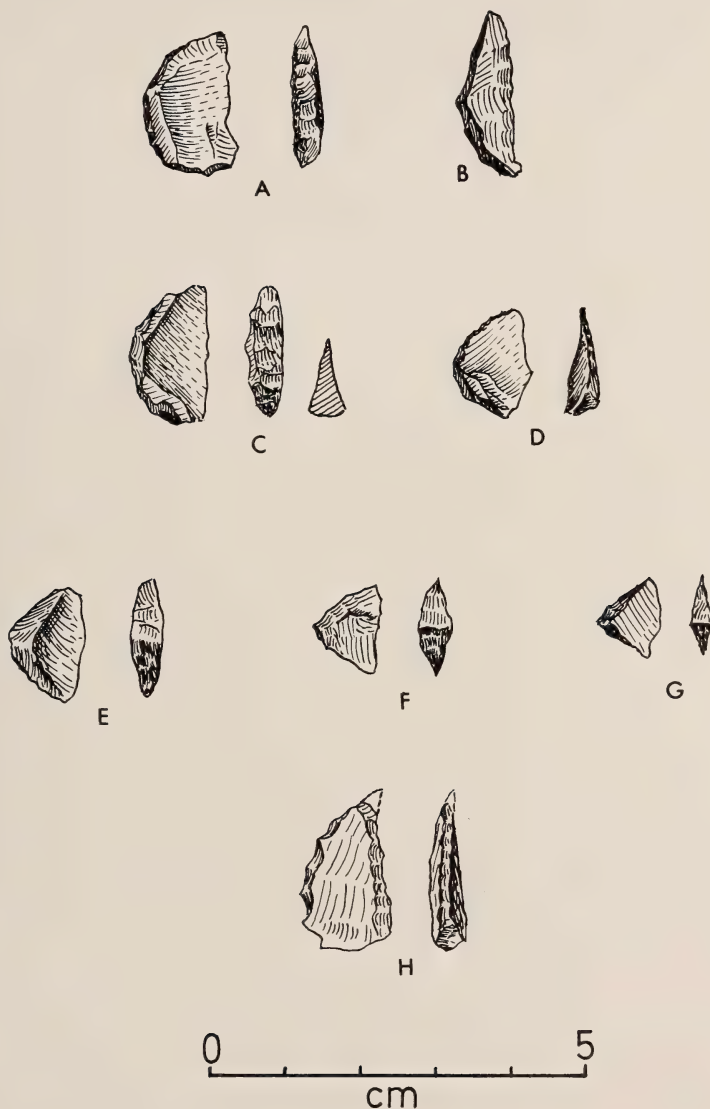


Fig. 43. A, D-E. Segments, chalcedony. B, F-G. Segments, quartz. C. Segment, silcrete. H. Borer, quartz.



*Discussion*

In conclusion it must be noted that the artefacts are very varied and as a result formal patterning is weak. This makes for difficulties in applying even simple, broad classifications. The informal content of the assemblage is not regarded as being the result of any incompetence on the part of the tool makers, whose skills were turned to working other materials such as shell, bone and pottery, but rather as resulting from the differing needs arising from a stay at the coast.

## ANIMAL AND PLANT REMAINS

## SHELLFISH

The Holocene midden member in the Die Kelders sequence is largely composed of shell with interstitial sand, ash, and other inclusions. The exception is layer 12 which is an occupation soil rather than a shell-midden. Some layers (5, 8 and 9) have few inclusions other than shell and almost entirely represent garbage heaps. Shell, which contributes to the rapid build-up of deposits, is largely unweathered in this time range. Fragmentation, probably resulting mostly from trampling, is, however, a factor that must be taken into account and certain layers, especially in the main part of the cave, show a high degree of comminution; but on the whole the shell remains are readily identifiable.

There is little question that the bulk of the shell represents food residues. Shellfish are still collected and eaten by the local population and there are also good ethno-historical records of the importance of shellfish in the diet of the indigenous peoples at the time of the European contact. Shellfish eating was the hallmark of the 'Strandloper' and as Goodwin (1935: 293) notes, shell-middens were still in the process of formation in Van Riebeeck's time. This has since been confirmed by the discovery, during building excavations in the centre of modern Cape Town, of shell-middens whose upper layers included European goods of the early historic period (G. Avery pers. comm.).

The coastal zone offers a ready supply of food in the form of shellfish. Although something of the order of 75 per cent by mass of a shellfish is inedible, the edible portion is a good source of nourishment containing protein (10 g/100 g), fat (29 g/100 g), minerals and vitamins (Fox 1966: 38).

It has long been appreciated by archaeologists in South Africa that shellfish residues can be readily identified and that they provide useful dietary information as well as data on the selection and availability of different species in what is essentially a 'Strandloper' economy. Goodwin's collaboration with Barnard in reporting the shellfish remains from Klipkop Cave at Hermanus (Goodwin 1938a) is an example. What has developed since that time is an awareness that a species list alone is not very informative and that a more quantitative approach is desirable (Avery 1976; Deacon, H. J. 1970; Grindley 1967; Klein 1972; Maggs & Speed 1967; Speed 1969; Voigt 1973a, 1973b). However, sampling poses problems in quantification. If quantitative data on

relative frequencies of minimum numbers of individuals are to be interpreted in terms of exploitation patterns, it is necessary also to take into account the mean live mass of different species and the relative abundance of shellfish populations in the tidal zones of the locality.

### *The shell components of the middens*

#### *Sampling*

Since almost the entire deposit consisted of marine shell, it was considered impracticable to retain all the shell for laboratory analysis. Instead, after various sampling methods had been tried, what may be termed sieved bulk samples were collected. This entailed the retention of all the shell from parts of selected grid squares and natural stratigraphic units that remained after sieving on a 3-mm-mesh sieve. Dependent on the thickness of the stratigraphic unit, the shell content from one to three buckets (volume approximately 0,03 m<sup>3</sup>) was retained.

As will be seen from Table 19, the ratio of shell recovered from individual stratigraphic units relative to the excavated volume is extremely variable, from 85,7 per cent in layer 2 to 13,9 per cent in layer 12. This is in part a reflection of the nature of the deposit: layer 2 consisted mostly of loosely packed, unbroken shell with little sand, while layer 12 was a brown, sandy soil in which the shell was incorporated. However, as indicated in Table 20, most sieved bulk samples yielded 100–300 identifiable shells per bucket and this was considered adequate for statistical analysis.

The distribution of shell in a midden is important in that it can reflect social and economic factors, but its mode of deposition and subsequent disturbance results in complex stratigraphic patterns. In order to approximate more closely the collection of shellfish by the cave occupants during various periods of the midden build-up, some layers were subdivided into naturally occurring sub-units. It was not always possible, however, to achieve the same level of precision in the separation of these sub-units and this may to some extent account for sample variability. The extreme variability of the samples is well demonstrated in Tables 19–22 which show respectively the ratio of shell to excavated volume, the frequencies of genera in the individual samples, the frequencies of *Patella* (limpet) species and those of *Choromytilus meridionalis* (black mussel) and *Perna perna* (brown mussel). Not only is there a wide range of variation in the amount of shell recovered from different grid squares and layers, but there is also wide variation in cases where more than one sample was taken from the same layer of the same square (e.g. square C8, layer 7) or from adjacent squares of the same layer sub-unit (e.g. squares B2 and C2, layer 3b) (Table 20). While this sort of variability is not unusual in most types of excavation, it adds to the complexity of interpreting patterns of behaviour from the midden refuse.

Two other factors influence sample variability. One is the change in

TABLE 19  
Marine shell: excavated volumes per layer of sieved bulk samples.

Layer	1	2	3	3b	4	5	5b	6	7	8a	8b	9	10	12
Volume of deposit excavated . . . . . m <sup>3</sup>		2,2	1,4	0,7	0,6	4,1	1,5	0,5	1,0	6,6	2,7	0,6	5,0	8,6
Volume of shell . . . . . m <sup>3</sup>		0,5	1,2	0,3	0,4	2,4	0,5	0,1	0,4	3,3	1,2	0,2	3,4	1,2
Volume of shell as % of deposit . . . . .		22,7	85,7	42,9	66,7	58,5	33,3	20,0	40,0	50,0	44,4	33,3	68,0	13,9

TABLE 20  
Marine shell: genera from sieved bulk samples.

Square	Layer	Bullia		Burnupena		Turbo		Oxystele		Haliotis		Patella		Chiton		Choromytilus and Perna		Donax		Layer total		% sample total
		%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	
A8 . . . . .	1	4,2	2	14,9	7	—	—	4,2	2	—	—	4,2	2	—	—	73,3	34	—	—	99,8	47	0,2
AA3 . . . . .	2a	—	—	7,7	18	11,1	26	1,3	3	—	—	1,7	4	—	—	78,3	184	—	—	100,1	235	1,1
AA3 . . . . .	2b	—	—	10,6	57	0,9	5	3,2	17	0,9	5	6,0	32	—	—	78,3	419	—	—	99,9	535	2,6
AA5 . . . . .	2b	—	—	15,5	109	0,4	3	3,7	26	0,1	1	2,6	18	—	—	77,7	547	—	—	100,0	704	3,4
B1 . . . . .	2b	—	—	6,5	21	0,9	3	1,8	6	—	—	1,8	6	—	—	88,9	289	—	—	99,9	325	1,6
AA3 . . . . .	3	1,7	2	13,0	15	1,7	2	—	—	—	—	0,9	1	—	—	82,6	95	—	—	99,9	115	0,5
AA5 . . . . .	3	0,8	8	22,8	237	2,0	21	9,5	99	0,8	8	6,5	22	—	—	57,5	597	—	—	99,9	1038	5,0
B2 . . . . .	3b	—	—	6,9	17	1,6	4	0,8	2	—	—	3,3	5	—	—	81,7	201	—	—	99,9	246	1,2
B2 . . . . .	3b	—	—	18,3	28	5,2	8	14,4	22	—	—	3,3	5	0,6	1	58,2	89	—	—	100,0	153	0,7
B2 . . . . .	3c	—	—	30,3	27	4,5	4	10,1	9	—	—	8,9	8	—	—	45,8	38	—	—	99,9	89	0,4
AA3 . . . . .	4	3,4	3	14,6	37	8,7	22	19,4	49	1,2	3	10,3	26	—	—	45,8	116	—	—	100,0	253	1,2
AA5 . . . . .	4	0,3	5	26,3	492	2,7	50	12,2	229	0,3	6	4,4	78	0,1	3	53,9	1008	—	—	100,0	1870	9,0
AA6 . . . . .	4	0,2	2	12,2	116	2,1	20	8,4	80	0,3	3	4,4	42	0,3	2	72,0	684	—	—	99,9	950	4,6
C2 . . . . .	4	0,2	1	17,9	77	3,0	26	13,5	26	1,6	7	8,1	35	—	—	52,6	226	—	—	99,9	430	2,1
B2 . . . . .	4	—	—	25,5	77	6,0	11	8,6	26	2,3	7	11,9	36	0,3	1	47,7	144	—	—	99,9	302	1,4
AA2 . . . . .	5	—	—	13,2	39	1,3	14	5,4	16	1,0	3	3,4	10	0,3	1	75,3	223	—	—	99,9	296	1,4
AA5 . . . . .	5	—	—	21,0	296	0,9	13	5,6	79	0,7	10	7,2	102	0,1	1	64,4	906	—	—	99,9	1407	6,8
C2 . . . . .	5b	0,5	3	9,2	22	1,3	3	15,1	36	0,8	2	4,2	21	—	—	68,9	164	—	—	99,8	238	1,1
AA5 . . . . .	6	—	—	17,5	110	0,3	5	4,3	27	0,5	3	3,3	21	—	—	73,0	458	—	—	99,9	627	3,0
AA7 . . . . .	6b	—	—	34,3	282	2,7	19	10,4	86	0,1	1	1,4	77	—	—	43,5	358	—	—	100,0	823	4,0
AA5 . . . . .	7	0,9	6	18,5	120	1,7	11	8,3	54	0,5	3	3,2	86	—	—	53,8	349	—	—	100,0	649	3,1
A6 . . . . .	7	0,4	2	15,0	84	1,7	7	5,2	29	0,4	2	4,7	23	—	—	77,9	409	—	—	100,1	561	2,7
A8 . . . . .	7	—	—	17,5	17	2,1	2	5,1	5	—	—	19,0	19	—	—	55,7	54	—	—	100,0	97	0,5
C8 . . . . .	7	—	—	11,5	27	1,7	4	—	—	—	—	3,6	5	—	—	84,7	199	—	—	100,0	235	1,1
C8 . . . . .	7	—	—	41,4	48	2,9	18	0,3	2	1,8	11	4,6	115	—	—	65,3	403	—	—	99,9	617	3,0
D10 . . . . .	7b	—	—	1,7	4	1,7	2	—	—	—	—	18,6	5	—	—	50,9	59	—	—	100,0	116	0,6
AA5 . . . . .	8a	—	—	22,3	107	3,3	4	5,0	6	—	—	9,0	12	—	—	56,8	273	—	—	100,0	480	2,3
AA8 . . . . .	8a	—	—	5,7	25	2,0	9	10,6	51	—	—	9,0	43	—	—	88,9	273	—	—	99,9	441	2,1
A7 . . . . .	8a	—	—	6,8	14	1,0	2	1,1	5	1,1	5	1,6	7	—	—	86,4	390	—	—	100,0	480	2,3
A8 . . . . .	8a	—	—	7,0	40	1,9	11	2,9	8	1,0	2	1,9	37	—	—	80,7	179	—	—	100,0	205	1,0
AA6 . . . . .	8a	—	—	17,6	40	2,4	16	1,4	8	2,5	14	2,3	15	—	—	80,7	460	—	—	100,0	570	2,7
AA6 . . . . .	8b	0,3	2	17,6	117	2,4	16	2,3	15	0,9	3	3,1	5	—	—	74,5	495	—	—	100,0	664	3,2
AA7 . . . . .	8b	—	—	9,4	15	3,1	2	—	—	—	—	3,1	5	—	—	77,7	108	—	—	100,0	160	0,8
A8 . . . . .	8b	—	—	11,5	16	1,4	2	4,3	24	1,4	2	3,8	44	—	—	65,7	1025	—	—	99,9	139	0,7
AA4 . . . . .	10	0,4	6	28,0	436	0,4	6	1,5	24	1,4	18	2,8	19	—	—	75,1	1937	—	—	100,1	1559	7,5
AA5 . . . . .	10	—	—	20,2	149	1,8	8	1,9	14	1,6	12	2,6	46	—	—	82,5	1072	—	—	100,1	1739	3,6
AA5 . . . . .	10	—	—	9,5	124	1,8	24	1,5	20	1,0	13	3,5	10	—	—	75,1	537	—	—	99,8	1299	6,3
A7 . . . . .	10	0,3	1	8,0	26	2,6	12	0,9	3	0,9	4	3,1	28	—	—	82,5	284	—	—	100,1	324	1,6
AA5 . . . . .	12	0,7	3	12,4	56	5,2	17	23,4	106	0,9	4	6,4	55	—	—	53,9	244	—	—	100,1	453	2,2
AA5 . . . . .	12	0,3	1	2,1	7	5,2	17	6,4	21	0,9	3	16,3	55	—	—	61,6	202	—	—	100,0	328	1,6
A6 . . . . .	12	0,3	1	2,5	8	7,0	22	4,1	13	3,2	10	36,3	114	—	—	41,7	131	—	—	99,9	314	1,5
Genus total		48		3 588		437		1 260		165		1 299		9		13 884		64			20 754	
% sample total		0,2		17,3		2,1		6,1		0,8		6,3		0,04		66,9		0,3				



sampling procedure during the excavation, which resulted in more sieved bulk samples from some squares or layers than had been taken in previously excavated parts. The second is that it was only at the stage of laboratory analysis that the importance of recording the different degrees of shell fragmentation in the various strata was fully appreciated. It is evident that the more fragile shells such as *Choromytilus* and *Perna* are more susceptible to fragmentation due to trampling and burning than the more robust genera such as *Patella* and *Burnupena*. Table 20 indicates that, where there is a decrease in the frequency of the more fragile shells, there is a corresponding increase in that of the more robust ones, and the high frequency of *Burnupena*, e.g. in square AA7, layer 6 and square C8, layer 7, is probably indicative of a high degree of fragmentation of the more fragile shells. However, since counts were not restricted only to complete shells but also included identifiable parts large enough to be retained on the 3-mm-mesh sieve, this factor is not considered to have added significantly to possible sample bias resulting from the other factors mentioned.

#### *Identification and quantification*

The identification of the shells was based on their gross morphological character. This was relatively easy in most cases, although affected by break-ages and colour fading. Generally the most durable shells were found to be *Patella* and *Burnupena*, whilst *Choromytilus*, *Perna*, *Haliotis*, *Turbo* and *Oxystele* are generally more fragmented in the samples. Counts were made on such identifiable features as umbones (left and right) in *Choromytilus* and *Perna*, spires in *Haliotis*, apices in *Oxystele* and *Burnupena*, and both apices and opercula in *Turbo*, where the highest counts are normally given by the opercula. No complete shells of less than 2 cm maximum length were included in the counts as they were considered to have been too small to have played any part in the diet. These include all *Crepidula porcellana* which are assumed to have been introduced into the deposit adhering to the outer shell of *Patella argenvillei*. Table 20 lists the counts from the various bulk shell samples. Because of the statistically low counts the main genera rather than individual species are listed. In addition, the mussels *Choromytilus meridionalis* and *Perna perna* are grouped together in the table because the genera are morphologically closely similar. Supplementary Tables (21 and 22) listing the species composition of the limpets and the mussels are also provided.

Table 20 indicates that the most commonly occurring genera are *Choromytilus* and *Perna*. These account for 66.9 per cent of the total shell sample, and range between about 40 and 90 per cent of the frequencies for individual samples, with twenty-two of the forty-one samples comprising over 70 per cent of these two genera. *Burnupena*, with 17.3 per cent of the total sample and individual frequencies ranging from about 2 to 41 per cent, is next in numerical frequency. The importance of *Burnupena* as a food source is debatable: its flesh is said to be bitter and unpalatable, but it occurs in frequencies that are generally too high for the possibility that the shells included in Table 20 merely



TABLE 21  
Marine shell: *Patella* species in sieved bulk samples.

Square	Layer	<i>P. argenvillei</i>	<i>P. barbara</i>	<i>P. cochlear</i>	<i>P. granatina</i>	<i>P. granularis</i>	<i>P. oculus</i>	Other	Layer total	% sample total
A8	1	—	—	1	1	—	—	—	2	0,1
AA3	2a	—	—	—	1	1	2	—	4	0,3
AA3	2b	4	—	4	12	4	—	8	32	2,5
AA5	2b	2	—	4	6	1	5	—	18	1,4
B1	2b	2	—	—	3	—	1	—	6	0,5
AA3	3	—	—	—	—	—	1	—	1	0,1
AA5	3	5	—	7	29	20	7	—	68	5,2
A2	3b	3	—	1	8	3	7	—	22	1,7
C2	3b	—	—	1	1	3	—	—	5	0,4
B2	3c	—	—	2	2	2	—	1	8	0,6
AA3	4	4	—	2	16	1	3	—	26	2,0
AA5	4	4	—	8	34	26	4	—	76	5,9
AA6	4	1	—	7	16	14	4	1	43	3,3
A2	4	6	—	—	25	3	1	—	35	2,7
B2	4	5	—	1	26	1	3	—	36	2,8
AA2	5	—	—	13	9	—	1	—	10	0,8
AA5	5	4	—	—	52	25	8	—	102	7,9
C2	5b	—	—	—	3	7	1	—	11	0,8
AA5	6	—	—	4	6	9	1	1	21	1,6
AA7	6	17	—	14	22	23	1	—	77	5,9
AA5	7	4	—	4	40	30	8	—	86	6,6
A6	7	—	—	—	12	11	—	—	23	1,8
A8	7	2	—	1	9	7	—	—	19	1,5
C8	7	1	—	1	2	1	—	—	5	0,4
C8	7	4	—	7	38	57	—	9	115	8,9
C8	7	—	1	2	—	2	—	—	5	0,4
D10	7	1	—	—	6	4	—	—	12	0,9
AA5	8a	19	—	4	11	8	1	—	43	3,3
AA8	8a	1	—	—	1	2	3	1	7	0,5
A7	8a	—	—	—	—	1	—	—	2	0,1
A8	8a	3	—	2	15	12	5	—	37	2,9
A8	8a	1	—	—	—	3	1	—	5	0,4
AA6	8b	—	—	—	10	3	—	—	15	1,2
AA7	8b	—	—	—	—	3	—	—	5	0,4
AA4	10	4	—	1	1	6	—	—	44	3,4
AA5	10	4	—	2	23	10	9	—	44	3,4
AA5	10	—	—	—	12	3	3	—	18	1,4
A7	10	2	—	—	4	4	—	—	10	0,8
AA5	12	7	—	4	14	—	3	—	28	2,2
A6	12	2	2	15	25	3	—	8	55	4,2
A8	12	13	1	1	89	3	5	2	114	8,8
Species total		126	4	115	605	316	96	33	1 295	
% sample total		9,7	0,3	8,9	46,7	24,4	7,4	2,5		

represent unworked shells brought into the cave for eventual ornamental use, since only twenty-two perforated examples were found (Table 4). Frequencies of other genera are mostly low, only rarely exceeding 10 per cent of individual sample totals, and the very low frequencies of *Bullia* and *Chiton* suggest that they are chance inclusions. It is possible that the *Bullia* are unworked shells that should perhaps be considered with the perforated shells (see Table 4 and p. 144).

Individual sample counts for *Patella* species given in Table 21 show a range of from 1 to 114 per sample. Of the six species represented *P. granatina* is most common (46,7% of the sample total) followed by *P. granularis* (24,4%). The high frequencies of these two species are doubtless the result of their being the two most common *Patella* species (Day 1969: 155, 156). The other four species are each present in frequencies lower than 10 per cent of the sample total. Although the sampling method does not allow for accurate assessment of change through time by the measurement of frequency differences between layers, calculation of the average shell count for each layer shows Layer 12 to have the greatest mean frequency (66). A decline in layers 10 and 8 is followed by increases in layers 7 and 6, when the frequency stabilizes until layer 4, but declines again in layers 3 to 1. In the context of the total marine shell component (Table 20) *Patella* frequencies are generally below 10 per cent, although three of the seven samples from layer 7 exceed this, as do two of the three from layer 12, that from square A8 yielding an exceptional 36,3 per cent. Layer 12 is also noteworthy in having yielded the widest range of species as well as some of the biggest individuals.

The sample totals for *Choromytilus* and *Perna* given in Table 22 show that frequency of the black mussel exceeds that of the brown by a factor of almost three to one, with individual sample frequencies of the latter ranging from 0 to 48,8 per cent. This is probably a reflection of the greater visibility and accessibility of *Choromytilus*. As mentioned in the foregoing discussion of the *Patella* species, the sampling procedure causes problems in the analysis of temporal change. In the case of the mussels, however, the mean frequency variation between layers is so great as to preclude any inferences regarding exploitation trends, and the same is true of the mean *Choromytilus* : *Perna* ratios. It is worth noting, though, that layer 10 has the highest mean frequency of all the layers for combined samples and for both genera (483 and 246 respectively). A factor that should be borne in mind when considering the range of variation between *Choromytilus* and *Perna* frequencies, particularly where more than one sample is represented from the same square and the same layer, e.g. square C8, layer 7, is that *Perna* is more fragile than *Choromytilus*, so that low frequencies of *Perna* may indicate a higher degree of fragmentation.

#### *Interpretation of shell counts*

It is apparent from the shell analysis of the Die Kelders middens that collecting of shellfish was directed primarily at *Choromytilus* and *Perna*. These

TABLE 22

Marine shell: *Choromytilus* and *Perna* in sieved bulk samples.

Square	Layer	<i>Choromytilus</i>		<i>Perna</i>		Total**	<i>Perna</i> as % of total
		L*	R*	L	R		
A8 . . . . .	1	21	19	13	11	34	38,2
AA3 . . . . .	2a	152	151	32	26	184	17,4
AA3 . . . . .	2b	267	217	152	145	419	36,3
AA5 . . . . .	2b	395	388	131	152	547	27,8
B1 . . . . .	2b	209	224	65	45	289	22,5
AA3 . . . . .	3	86	82	3	9	95	9,5
AA5 . . . . .	3	468	440	129	112	597	21,6
B2 . . . . .	3b	150	173	22	28	201	13,9
C2 . . . . .	3b	89	76	—	—	89	—
B2 . . . . .	3c	28	27	5	10	38	26,3
AA3 . . . . .	4	76	67	38	40	116	34,5
AA5 . . . . .	4	699	725	283	233	1 008	28,1
AA6 . . . . .	4	620	574	64	59	684	9,4
A2 . . . . .	4	170	174	52	52	226	23,0
B2 . . . . .	4	68	83	61	46	144	42,4
AA2 . . . . .	5	171	174	49	47	223	22,0
AA5 . . . . .	5	700	685	206	186	906	22,7
C2 . . . . .	5b	93	139	25	18	164	15,2
AA5 . . . . .	6	332	378	80	62	458	17,5
AA7 . . . . .	6	189	200	158	136	358	44,1
AA5 . . . . .	7	223	192	120	126	349	36,1
A6 . . . . .	7	168	190	219	210	409	53,5
A8 . . . . .	7	34	35	19	7	54	35,2
C8 . . . . .	7	171	187	4	12	199	6,0
C8 . . . . .	7	306	288	84	97	403	24,1
C8 . . . . .	7	34	42	6	17	59	28,8
D10 . . . . .	7	80	68	19	15	99	19,2
AA5 . . . . .	8a	220	212	50	53	273	19,4
AA8 . . . . .	8a	287	271	103	99	390	26,4
A7 . . . . .	8a	105	157	22	22	179	12,3
A8 . . . . .	8a	310	340	120	101	460	26,1
A8 . . . . .	8a	409	384	86	68	495	17,4
AA6 . . . . .	8b	102	111	21	19	132	15,9
AA7 . . . . .	8b	85	59	23	22	108	21,3
AA4 . . . . .	10	631	701	324	299	1 025	31,6
AA5 . . . . .	10	287	264	233	250	537	46,5
AA5 . . . . .	10	720	680	352	333	1 072	32,8
A7 . . . . .	10	224	200	60	48	284	21,1
AA5 . . . . .	12	184	165	60	50	244	24,6
A6 . . . . .	12	87	79	96	115	202	56,9
A8 . . . . .	12	50	67	64	63	131	48,8
Species total**		10 114		3 770		13 884	—
% sample total		72,8		27,1			

\* L = left umbo, R = right umbo.

\*\* Totals are based on the higher count, left or right, for each genus.

vary in size with age and there is a corresponding difference in flesh yield. An attempt was made to evaluate the size range of *Choromytilus* shells in the midden samples to gain a better appreciation of the food contributed by the mussel component. Some other larger shellfish that are represented by lower frequencies have a high value in flesh yield and their importance is not immediately apparent from simple counts.

A limited sample of shellfish was collected from the Blouberg beach near Cape Town, a locality some 140 km west of Die Kelders with somewhat colder water conditions. These factors are not, however, considered likely to have a significant effect on the comparability of the sample. The sample consisted of 100 *Choromytilus*, 50 *Burnupena*, 10 *Turbo sarmaticus* and 9 *Haliotis midae* and was collected during winter under a permit which restricts both the maximum number and minimum size of specimens. As far as possible collecting was aimed at different sized individuals in the various genera as interest was in the relationship between flesh yield and shell size. No attempt was made to sample the species composition of the intertidal fauna, although this is an obvious approach that should be borne in mind for future research, but would need to be carried out at Die Kelders specifically for it to have any direct relevance to the site.

Because of the fragmentation of *Choromytilus* in the midden sample, the morphological character chosen for size comparison with the modern sample was the width of the blue bands that are found on the interior of the valves. The blue band width range in the *Choromytilus* shells is between 3 and 9 mm and this range was divided into 3–5 mm, 5–7 mm and 7–9 mm classes. There was also a fourth class of indeterminate size for highly fragmented shells in the midden sample. In the modern samples different blue band widths gave the following average flesh mass: 3–5 mm = 3,0 g; 5–7 mm = 6,9 g; 7–9 mm = 30,7 g. The big mass increase in the largest class suggests that the blue band width increase is not a simple correlate of size. Most of the midden samples were in the 3–7 mm range, however, and the largest size of mussel was represented by less than 10 per cent in the 7–9 mm range. This fact may be seen as significant and possibly reflects collecting practices (see Buchanan *et al.* 1978: 91), although it is evident that the larger shells are thicker and thus less subject to fragmentation than the smaller, thinner ones. In the measured samples from the different layers it was thus *Choromytilus* in the 5–7 mm blue band width range that contributed the bulk of the flesh eaten. About 15 mussels of this size would yield 100 g of flesh and that amount would contribute some 70–90 calories (Fox 1966: 38). There would be an obvious advantage in the selection of larger mussels, but these are unlikely to be available in quantity in a regularly exploited mussel population. It can be expected that even a small human group would have been capable of serious depletion of the local mussel beds where the individual needs of a single member could have been between 100 and 200 mussels per day.

A relationship between flesh mass and operculum size was worked out



for the modern *Turbo* specimens collected, and on the basis of this admittedly small sample an estimated flesh mass of 20 g each was calculated for the *Turbo* represented by opercula found in the midden deposit. The flesh yield of *Turbo* is thus three times that of *Choromytilus*. *Haliotis* has an even higher yield: the flesh mass in nine mature modern specimens was found to be between 199 g and 433 g with a mean of 287 g. Conservation laws at present prohibit the collecting of immature individuals, that is *Haliotis* less than 12 years old (Rand 1971: 126). The shell of the immature *Haliotis* is very friable and as a consequence it is largely mature individuals that are represented in the deposit. In terms of yield one *Haliotis* shell in the midden is equivalent to some forty *Choromytilus* shells. Among the remaining shellfish eaten, *Oxystele* are similar in yield to *Choromytilus* but in general represent only some 10 per cent or less of the middens. The *Patella* are larger than the *Choromytilus* and *Perna* but tend to be represented in the middens in low percentages, except in layer 12.

The frequencies of shellfish found in the different layers in the late Holocene deposits at Die Kelders (Table 20) give an indication of the range of shellfish collected. Calculation of the yield in flesh mass of individual species, however, gives a slightly different perspective to the frequency counts.

### Conclusions

The earliest layer of the sequence, layer 12, although containing only some 14 per cent by volume of shell, includes the greatest variety of shellfish and also shells of generally larger size. This suggests the exploitation of a rich shellfish fauna that was available to the initial groups occupying DK 1. The midden accumulation overlying layer 12 seems to have been directed more towards the lower yielding but easily obtainable mussels, mainly *Choromytilus*, possibly because population pressures necessitated the exploitation of a wider subsistence base. Layer 12 and the overlying layers are, however, not directly comparable because the former is an occupation soil and the latter are refuse heaps. It should also be borne in mind that only a limited area of the cave has been excavated and possible occupation areas related to these refuse heaps may be located elsewhere. However, it is possible that the contrasts indicated point to two factors; firstly to a reduction through time in the richness and diversity of the shellfish fauna and secondly, and perhaps more probably, a change in the importance of shellfish in the economy during the later occupations. Layer 12 represents an occupation some 2 000 years ago when the population of the area were primarily hunter-gatherers visiting the coast during a restricted season. Their versatility in exploiting their environment is supported by evidence from other food and cultural remains. In the uppermost layers, up to 500 years younger, there is evidence of increased reliance on domestic animals and a more protracted season spent at the coast. The general visible emphasis throughout the occupation, however, continued to rest on mussel exploitation.

## FISH

The abundance of shellfood residues at most coastal cave middens tends to overshadow the presence of the less conspicuous fish remains. As the catching of fish would have been more demanding in skill and technology than the collecting of shellfish, prehistoric fishing methods have been a focus of interest of a number of investigators. In one of the earlier investigations Goodwin (1946: 134-141) described numerous coastal 'vywers' or tidal fish-traps, the remains of which are still to be found along the coast, and which in isolated instances are still in use today.

These traps consist of an enclosure which 'is built up as a dry-stone wall to such a height that normal high tides will cover the "vywer" and permit fish to swim freely over the enclosed area. As the tide sinks, the water runs out through the interstices between the stones, while the fish are trapped and can be clubbed and caught by hand. It is a simple application of the system used for netting fish, though here the dry-stone walling provides the imbrications' (Goodwin 1946: 134).

Goodwin, who recognized the problem of dating these fish-traps, suggested that the sudden proliferation in fish remains at Oakhurst and other middens in the 'developed Wilton' levels correlated with the construction of the traps. Avery's (1975) more recent observations on fish-traps between Walker Bay and Cape Agulhas, which include a record of catches from a functioning trap, support Goodwin's description of the traps and their efficiency as a means of catching fish. Evidence of other possible prehistoric fishing methods is mentioned by Goodwin (1946: 340) in quoting a letter received from a Mr Pike who reported the discovery of 'a fishing line made of a certain wild vine of fibrous nature. This has been shredded and turned into a fishing line and the hook was a bone tied in the middle and sharpened on each side.' At that time Goodwin had not found any fish gorges in midden deposits but they have subsequently been recovered from Nelson Bay Cave, Cape south coast (R. R. Inskeep pers. comm.; Deacon, J. 1978, figs 10-11) and from Elands Bay Cave, Cape west coast (J. E. Parkington pers. comm.). Other material evidence of line-fishing on the coast has come from the discovery of stone sinkers from Swarttrif midden, Cape south coast (Deacon, H. J. 1970: 43) and Nelson Bay Cave (R. R. Inskeep pers. comm.; Deacon, J. 1978, table 1). The spearing of fish from rocks or positions in the sea is depicted in prehistoric rock art (Willcox 1963: 28-30; Carter 1965: 579) and recounted by early travellers (Kolb 1738: 256-257) and seems well established as a further method that was used.

The quantity of fish bones clearly attests to successful fishing methods having been used at Die Kelders. In all probability a number of different techniques were used, depending on the sea conditions and the type of fish. Because of their maintenance needs the use of fish-traps would, however, imply relatively sedentary population and they may not have come into use until herding was established in the area.

*Sampling, identification and quantification*

All fish remains retained after sieving were identified as far as possible. They were found to belong to species still common in the area today. Counts were based on dentaries and premaxillae as these were found to be the best surviving bones in all the major levels. By far the greater number of fish recovered from DK 1 belong to the family Sparidae, members of which occur in all but the coldest seas of all oceans and are usually concentrated along the shore in fairly shallow water (Smith 1949: 265). Some species enter and live in estuaries while others penetrate deeper water. The fish of this family represented at DK 1 are *Pachymetopon blochii* (hottentots), *Lithognathus lithognathus* (white steenbras), and *Cymatoceps nastutus* (mussel-cracker or biskop), all of which are still commercially important.

The total counts and the distribution of the fish remains throughout the deposits, shown in Table 23, reflect the major role *Pachymetopon blochii* played in supplying the fish food during the midden build-up. From the beginning of the Holocene occupation, this well-known fish, which frequents deepish waters in rocky areas on the Cape west coast mainly west of Cape Agulhas, accounted for some 92 per cent of the total number of fish brought back to the site. The high count of individuals does not necessarily reflect a high yield of edible flesh. *P. blochii* may obtain a length of 45 cm but are generally much smaller (Smith 1949: 276).

The next most numerous fish remains at DK 1 are of *Lithognathus lithognathus* which is found along all South African coasts. It has a habitat preference for waters with a sandy bottom. Although this fish may attain a length of 180 cm, jawbones from DK 1 suggest a size range considerably below this. In their search for food, white steenbras usually enter shallow water and adopt a characteristic feeding attitude, head downwards on to the sea floor, the body in an almost vertical position with the tail acting as a propeller, forcing the pointed mouth into the sand (Biden 1954: 252). In this position they would be most vulnerable to spearing or even catching by hand. *Rhabdosargus globiceps* (white stumpnose), represented in the samples, also occurs all along the local coast. It attains a length exceeding 50 cm. Today it is usually caught close inshore by nets or line. *Cymatoceps nastutus* occurs in lower frequency in the samples. It may attain a mass of up to 20 kg, and exceed 45 cm in length. Found only off the South African coast, nowhere abundant, it frequents rocky areas and often feeds in shallow water (Smith 1949: 271).

Other families which were represented in smaller numbers in the deposits are as follows:

The Coracinidae, represented by *Coracinus capensis* (galjoen), are found in shallow and turbulent waters all along the coast. They average about 1,4 kg and form shoals in winter (Smith 1949: 248).

The Pomatidae, represented by *Pomatomus saltatrix* (elf), are found in all but the coldest waters in all oceans and attain a length exceeding 122 cm (Smith: 1949: 224).



The category 'other' (Table 23) comprises nine individuals; 2 *Liza richardsonii* (haarders) from layer 12; 1 *Tachysurus feliceps* (sea barbel) from layer 12; 3 *Pomadysis comersonni* (grunter), 1 from layer 7, 2 from layer 2; 1 *Diplodus trifasciatus* (zebra) from layer 10; 2 *Seriola lalandii* (yellowtail) from layer 12. These numbers are considered to be too low to be significant.

### *Fishing methods*

Whilst it was generally possible to identify the remains, it is more difficult to determine the methods used for catching the fish. This is due mainly to the absence of direct material evidence of fishing practices. However, some inference can be drawn from the behaviour of different species.

As *Pachymetopon blochii* tend to frequent areas of kelp, it is unlikely that they could have been speared successfully, given the depth of water and poor visibility under the cover of the kelp. The use of tidal fish-traps to catch this species is thought equally unlikely as the coastline near DK 1, where rocky, is too steep and is broken only by narrow gullies. Again, the use of these traps can be considered unlikely because of the near absence of *Liza richardsonii* in the fish remains. These fish, which are distributed all along our coasts, feature most prominently in fish counts derived from a still-operative fish-trap situated at Die Dam, some 30 km east of DK 1 (Avery 1975). They would, therefore, reasonably be expected to have formed part of the catch had small traps been built at or near DK 1 or had fish been brought from the nearest known trap sites clustered close to Danger Point about 10 km to the south (G. Avery pers. comm.). This strongly suggests the possibility that *P. blochii* were caught on lines. In line-fishing for them, sea-worms or rock-lobster can be used as bait (Biden 1954: 232), or simply a bunch of limpets on a line if some sort of scoop net is available (M. J. Penrith pers. comm.). Unfortunately there is little direct evidence to support line-fishing, as only one or two bone points have been recovered at DK 1 that could possibly be classified as fish gorges. This is in contrast with large numbers recovered at Elands Bay to the west and Nelson Bay Cove to the east and may be accounted for by temporal factors, as the Elands Bay and Nelson Bay gorges are dated to occupations several thousand years earlier than those at DK 1. However, there were no finds of line or netting at Die Kelders and the evidence for line-fishing is thus somewhat inconclusive at present.

The capture of *Lithognathus lithognathus* could have entailed the use of spears, as mentioned earlier. The success of this method has been recorded in the *Journal* of Van Riebeeck (Moodie ed. 1838: 93): the entry for 20 January 1657 records that people of the Hottentot tribe known as the 'Caepmans' (Goringhaiqua) 'came with 10 oxen laden with *steenbrasen*, which they had this morning killed with assegays in some shallow water near False Bay . . . enough to feed the garrison for 3 or 4 days'. More recent confirmation of the use of this method was reported from Walvis Bay by Biden (1954: 253), who describes the spearing of these fish with straightened fish-hooks attached to '4 ft' (1,2 m)



TABLE 23  
Fish species.

Layer	1	2	3	4	5	6	7	8	9	10	12	15	17	20	22	22b	22c	Species total	Sample total	% sample total
<i>Pachymetopon blochii</i>	41	209	141	546	227	116	627	291	89	637	1 334	62		18	22	22	18	4 400		96,4
<i>Lithognathus lithognathus</i>	3	13	12	32	10	10	10	7		12	18	9	1		6			143		3,0
<i>Rhabdosargus globiceps</i>	3	2	1		1	2	9	3		15	19		2					57		1,2
<i>Rhabdosargus sarba</i>		2					1											3		0,1
Other Sparidae																				
Indeterminate	1	3	1	3		8	2	2	2	4	49							73		1,5
<i>Cymatoceps nasutus</i>						2	3	1	1		8				7			24		0,5
<i>Coracinus capensis</i>						1	3	1		2	20							28		0,6
<i>Pomatomus saltatrix</i>	1	1	2	1		1	2		5	4	3							20		0,4
<i>Diplodus sargus</i>							1	2			1							4		0,1
Other		2					1			1	5							9	4 761	0,2
Layer total	49	234	157	582	238	140	659	305	97	675	1 457	71	3	19	35	22	18			
% sample total	1,0	4,9	3,3	12,2	5,0	2,9	13,8	6,4	2,0	14,2	30,6	1,5	0,1	0,4	0,7	0,5	0,4			

sticks. Whilst no such sticks were found at DK 1, there are numbers of bone points in the deposits which might have served as projectile tips.

While there is thus no incontrovertible evidence to support the use of any of the fishing methods discussed, the use of lines and spears or harpoons is likely. Line-fishing may have been the most important method and on present indications tidal traps were probably not used by the Die Kelders fishermen.

### *Fishing and economy*

The data set out in Table 23 reveal that *Pachymetopon blochii* were the staple fish diet throughout the accumulation of the DK 1 deposits. In layers containing at least 50 fish, this species formed 83–95 per cent of the total. Their numbers (1 334) in layer 12 show that fishing methods were competently practised from the beginning of the late Holocene cave occupation. The next most common fish was generally *Lithognathus lithognathus*, though with frequencies considerably below those of *P. blochii*. Other fish were far less numerous, only rarely exceeding 2 per cent of any layer total.

It is not possible to measure the overall significance of the fish component in the food remains at DK 1 in dietary terms without a more complete study of the relationship between the size of dentaries and live fish weights. Comparison could then be made between fish remains and shellfish or other food remains in terms of calories. Such an investigation relies on an extensive programme of sampling modern fish populations such as that being carried out by C. Poggenpoel of the University of Cape Town, but lies outside the scope of this investigation. However, to test the feasibility of such an approach six *P. blochii* were measured and weighed (Table 24), but in such a small sample

TABLE 24  
Fish: *Pachymetopon blochii*; measurements and flesh mass.

Specimen No.	Skeletal part	Max. length (mm)		Max. height (mm)		Max. thickness (mm)		Mass (g)
		L	R	L	R	L	R	
1 . . .	Premaxilla	13,32	13,27	10,11	10,05	2,80	2,75	226
	Dentary	14,07	14,32	9,47	9,63	2,98	3,30	
2 . . .	Premaxilla	12,80	12,99	10,32	10,05	2,35	2,49	194
	Dentary	13,05	13,12	8,64	9,28	2,61	2,54	
3 . . .	Premaxilla	13,16	13,00	10,00	10,00	2,28	2,45	179
	Dentary	13,05	13,24	9,46	9,36	2,51	2,50	
4 . . .	Premaxilla	13,88	14,06	11,20	10,75	2,51	2,59	200
	Dentary	± 13,95	13,81	± 10,04	10,01	2,71	2,90	
5 . . .	Premaxilla	12,25	12,15	10,01	10,12	2,21	2,18	152
	Dentary	11,71	11,90	9,21	9,30	2,35	2,28	
6 . . .	Premaxilla	25,45	25,25	19,85	19,85	4,99	4,98	1 031
	Dentary	25,62	25,72	17,10	17,01	4,82	4,95	

Note. L, R = Left, Right.

the correlation coefficient between jaw lengths and body weights was found to be too unreliable to allow meaningful interpretation. The nutritional value of this fish in the diet of the cave occupants is, however, indicated by the values of protein (18,8 g/100 g) and oil (1,97 g/100 g) reported in the literature (Fox 1966, table 36). Even allowing for 50 per cent loss of total mass for such inedibles as skin and bones, the edible residue of fish would have contributed a significant source of protein, given the numbers represented in the deposit.

#### BIRDS

At present only the bird fauna from layers 1 to 4 has been analysed and the counts are shown in Table 25. G. Avery, who undertook the identifications,

TABLE 25  
Birds: layers 1-4.

Species	Common name	Layer				Environment
		1	2	3	4	
<i>Spheniscus demersus</i>	Jackass penguin	1	2	1	4	Marine
Family Diomedidae	Albatross spp	1	—	—	2	
Family Procellariidae	Petrel, small spp	—	—	—	2	
Family Procellariidae	medium spp	1	—	—	1	
<i>Morus capensis</i>	Cape gannet	2	13	2	6	
<i>Phalacrocorax carbo</i>	White-breasted cormorant	1	1	—	1	
<i>Phalacrocorax capensis</i>	Cape cormorant	2	3	1	3	
<i>Phalacrocorax neglectus</i>	Bank cormorant	—	1	—	1	
<i>Larus dominicanus</i>	Southern black-backed gull	—	1	1	1	
Family Anatidae	Duck spp	—	1	1	1	Fresh-water
<i>Fulica cristata</i>	African coot	—	2	—	2	
<i>Francolinus capensis</i>	Cape francolin	1	—	—	—	Terrestrial
<i>Falco rupicolus</i>	Rock kestrel	1	1	—	—	Terrestrial: may nest on ledges, probably natural occurrence in deposit
Order Falconiformes indet.	Raptorial	—	—	—	1	
Order Strigiformes indet.	Owl spp	—	1	—	—	
<i>Corvultur albicollis</i>	White-necked raven	—	—	—	1	
Family Sturnidae	Starling	1	2	1	2	
Total . . . . .		11	28	7	28	

Table compiled by G. Avery

is of the opinion (pers. comm.) that the species listed and the proportions in which they are represented reflect a general pattern of bird-hunting indicated in other local Holocene middens.

It can be seen from the table that marine birds make up the bulk of the bird assemblage. When measured against the total of all bird remains, marine birds account for 74 per cent. This is increased to some 87 per cent if five out of the six terrestrial bird classes are excluded on the grounds that their presence may simply have been due to their habit of nesting on near-by ledges (G. Avery pers. comm.).

The frequency of bird remains in the top middens is low relative to other classes of food remains and it is evident that in these layers the sea birds, which form the bulk of the bird fauna, did not represent a major food resource. Indeed, the bird fauna may have had even greater value as a source of long, light shafts of bone for artefact use. Little can at present be said about the

methods used for hunting these birds except to mention that cormorants usually occur in large flocks, frequently settling on near-by rocks (McLachlan & Liversidge 1970: 24) where they would have presented no problem to hunters equipped with bows and arrows, clubs or snares. Gannets do not at present come close inshore and the remains at the site may be derived from birds washed ashore (G. Avery pers. comm.). One unusual find at the site was the partly articulated skeleton of a gannet found in layer 10 in the eastern part of the grid. This gannet was apparently not butchered and could be a natural inclusion.

#### REPTILES

Reptile remains at DK 1 are dominated by the tortoise *Testudo angulata*. Evidence from the lower (M.S.A.) levels indicates that these slow-moving ground game have been a source of food in the Gansbaai area since the first known human settlements there, some 80 000 years ago. But their survival is threatened by the increase in land under cultivation, by collecting, and by their continued use as food, both in small numbers by farm labourers and in large quantities at farm 'braais' (barbeques) (Rau 1969: 43).

Tortoise counts from DK 1 (Table 26) show that the early occupants of the cave during the late Holocene (layer 12) relied less on these animals as a

TABLE 26  
Reptiles: tortoises (minimum numbers of individuals).

Layer	1	2	3	4	5	6	7	8	9	10	12	22	Total
Individuals	—	42	18	22	5	4	120	38	8	74	17	10	358
% of total	—	11,7	5,0	6,1	1,4	1,1	33,5	10,6	2,2	20,7	4,7	2,8	99,9

source of food than did their successors, and that they were more successful predators of mammals and fish (Tables 23 and 27). As mentioned in the preceding section, tortoises were of value not only as food, but their carapaces were also modified to serve as containers.

Snakes, both poisonous and non-poisonous, are fairly common in the Gansbaai area, though rarely seen. Vertebrae and isolated jaw fragments were found in all layers of the deposit. These have not been identified but are believed to be principally mole snakes (*Pseudaspis cana*) which are the main species in the area. They are non-venomous and kill their prey, mainly moles, dune mole-rats, field rats and vlei rats by constriction (FitzSimons 1912: 98–100). Some of the vertebrae were heavily ochre-stained and may have been threaded for use as necklaces.

#### MAMMALS

##### *Domestic animals*

The introduction of domestic animals may be presumed to have brought about important changes in the ecology of the peoples in the Die Kelders area. The changes may have included an increase in population density following more settled existence related to animal husbandry, whether or not the cave



occupants were themselves the herders, and a decrease in the importance of hunting. In part these changes can be documented by the Die Kelders evidence. Of importance here, however, is the direct evidence at DK 1 for the appearance of herding. The occurrence of domestic sheep in prehistoric times at the Cape was first demonstrated at Die Kelders and was later confirmed by finds at other late Holocene sites. At numbers of these sites of later Holocene age studied or under study there appears to be a close link between the introduction of sheep, probably also cattle, and pottery.

### *Sheep (Ovis aries)*

In previous publications dealing with the sheep remains at Die Kelders (Schweitzer 1974; Schweitzer & Scott 1973), these were described as being restricted mainly to layer 2a-b, with minor additions from layers 1 and 3. Recent re-examinations of the faunal remains have, however, resulted in the addition of a further five individuals, bringing the total sample count of firmly identified animals up to thirty (Table 27). Layer 2a-b remains the main sheep-

TABLE 27

Mammals: Species list. Minimum numbers of individuals by which different mammalian species are represented in the Later Stone Age horizons of Die Kelders 1 (Klein & Scott unpublished). Stratigraphically lower units to the right.

Layer	1	2	20	22	3	4	5	6	7	8	9	10	12
<i>Papio ursinus</i> , chacma baboon	—	1	1	1	1	1	—	—	1	1	1	1	3
<i>Homo sapiens</i> , man	—	1	1	2	—	1	—	—	—	—	—	—	—
<i>Canis mesomelas</i> , jackal	—	—	—	1	—	—	—	—	—	—	—	—	1
<i>Canis familiaris</i> , dog	—	?1	—	—	—	—	—	—	—	—	—	—	?1
<i>Ictonyx striatus</i> , zorilla	2	1	—	—	—	—	—	—	1	—	—	—	4
<i>Mellivora capensis</i> , honey-badger	—	—	—	1	—	—	—	—	1	—	—	1	1
<i>Genetta</i> sp(p), genets	—	2	1	1	—	1	—	—	1	—	1	1	1
<i>Herpestes pulverulentis</i> , Cape grey mongoose	—	1	—	—	—	—	—	—	1	—	—	1	1
<i>Felis libyca</i> , wild-cat	1	—	1	—	—	—	—	—	—	1 cf.	—	1	1
<i>Felis</i> cf. <i>serval</i> , serval	—	—	—	—	—	—	—	—	1	—	—	—	1
<i>Panthera pardus</i> , leopard	—	—	—	1	—	—	—	—	—	—	—	—	1
<i>Arctocepalus pusillus</i> , Cape fur seal	4	5	2	7	4	8	2	3	10	3	2	10	41
<i>Mirounga leonina</i> , elephant seal	—	—	—	—	1	—	—	—	—	—	—	—	1
<i>Procavia capensis</i> , hyrax	1	8	2	3	1	3	1	3	1	1	1	1	5
<i>Loxodonta africana</i> , African elephant	—	—	—	1	—	—	—	—	—	—	—	—	—
<i>Diceros bicornis</i> , black rhinoceros	—	1	—	—	—	—	—	—	—	—	—	—	1
<i>Hippopotamus amphibius</i> , hippopotamus	—	—	—	—	—	—	—	—	—	—	—	1	—
<i>Porcochoerus porcus</i> , bush-pig	—	—	—	—	—	—	—	—	—	—	—	—	1
<i>Syncerus caffer</i> , buffalo	—	—	—	—	—	—	—	—	—	—	—	—	—
<i>Bos taurus</i> , cattle	?1	—	—	?1	—	?1	?1	—	1	1	?1	2	7
<i>Tragelaphus scriptus</i> , bush-buck	—	?2	—	—	—	—	—	—	—	—	—	—	—
<i>Hippotragus leucophaeus</i> , blue antelope	—	—	—	—	—	—	—	—	—	—	—	—	—
<i>Alcelaphus buselaphus</i> , hartebeest	—	?1	—	—	?1	—	—	—	?1	—	—	—	—
<i>Damaliscus dorcas</i> , bontebok	—	—	—	?1	?1	?1	—	?1	?1	—	—	1	?1
<i>Raphicerus melanotis</i> , grysbok	8	10	—	4	3	4	—	—	20	6	1	16	26
<i>R. campestris</i> , steenbok	12	2	—	2	—	—	—	—	5	4	—	3	13
<i>Raphicerus</i> spp, grysbok/steenbok	11	12	—	5	3	5	1	1	30	9	3	26	50
<i>Oreotragus oreotragus</i> , klipspringer	—	—	—	?1	—	—	—	—	—	?1	—	—	1
<i>Pelea capreolus</i> , grey rheebuck	—	—	—	?1	?1	?1	—	—	?1	—	—	?1	?1
<i>Ovis aries</i> , sheep	7	18	?1	?1	1	1	1	?1	1	?1	—	1	—
<i>Hystrix africae-australis</i> , porcupine	—	—	—	—	—	—	—	—	1	—	—	1	1
<i>Bathyergus suillus</i> , mole-rat	21	52	—	50	36	103	21	14	146	25	20	227	727
<i>Lagomorpha</i> (2 spp), hares	—	2	—	—	—	—	—	—	1	—	—	1	2
<i>Cetacea</i> , cetaceans	—	1	—	1	1	1	2	—	—	1	—	1	1

bearing horizon with a total sample of eighteen sheep. The remainder, which were mainly identified from teeth and jaw fragments, were found in layers 1, 3-5, 7 and 10 (R. G. Klein pers. comm.), thus confirming the previous tentative suggestion (Schweitzer 1974: 81) of the presence of sheep from the time layer 10 was deposited some 2 000 years ago. It should be noted that all sheep remains were limited to the above-mentioned layers, which are sheil-middens, and no sheep bones at all were found in the clearly demarcated and extensively excavated occupation horizon, layer 12, which generated over 1 000 well-made potsherds, and which was dated to  $1960 \pm 85$  B.P. (GX-1688). Support for the early arrival of sheep in the area comes from Avery's (1975: 112) excavation at Hawston, from a layer dated to between  $1860 \pm 60$  B.P. (Pta-834) and  $1900 \pm 40$  B.P. (Pta-835) as well as from recent excavations at Byneskranskop (R. G. Klein pers. comm.) for which a date of  $1880 \pm 50$  B.P. (Pta-1865) has been obtained from a layer containing both sheep remains and pottery.

The age groups reflected by these additional remains support the dominance of immature animals in the previously established age group patterns. As the additional material is mainly dental it does not contribute any new data on the sex ratios of the sample. Comparisons based on tooth eruptions in living animals must perforce incorporate a margin of error when related to skeletal remains which lack gums, and the potential errors are further increased by subjectivity in assigning border-line cases in age groupings. Further, age is more difficult to determine in older specimens. The dominance of young males and older females, based on the frequency of horn cores in the sample, was used to support an argument that systematic herding was practised (Schweitzer 1974: 79-80). It has since been established by G. Avery (pers. comm.) that over 60 per cent of all 'indigenous' Namaqua Afrikaner female sheep at Carnarvon, Cape, experimental station have horns. The validity of the argument may, therefore, be somewhat weakened.

It is not inconceivable, however, that the sheep that were eaten during the earlier time of the cave occupation were gained by theft or barter and that the cave occupants then were hunter-gatherers, but in layer 2 times the occupants may well have been managing sheep flocks and in this sense would have been herders.

#### *Cattle (Bos taurus)*

In addition to domestic sheep, the faunal remains from layer 2 probably also include cattle. At present the matter of identification is complicated by the dental and osteological similarities between young cattle and immature buffaloes, and positive identification must await the further study of comparative material.

#### *Domestic dog (Canis familiaris)*

Positive identification of the domestic dog has not been possible because of a paucity of comparative material and the small sample, as well as the possibility of confusion with jackal remains. The remains recovered were a metatarsus

in layer 12 and a scapula in layer 2, both of which fall outside the observed normal range for jackals.

### *Discussion*

Interest in the domestic sheep remains stems mainly from the early dating and the association with well-developed pottery. The finds place the introduction of herding at a period somewhat earlier than the earliest known Iron Age occurrences of domestic animals in the Transvaal (Mason 1973: 324–5; Welbourne 1973: 325). This poses the question of the processes involved in the introduction of domestic animals and pottery in pre-Iron Age times. There is at present no direct evidence for an invasion by a different kind of people, but the animals and the pottery are clearly exotic. The domestic animals did not migrate of their own accord and, as there are good historical examples of major translocations of groups of people of varying size, it is probable that the migration of people was also involved in some degree. It has been suggested (Deacon, H. J. 1974) that the appearance of herding in the southern Cape is related to the expansion of Bantu-speaking peoples and is thus part of the major demographic, economic and cultural changes southern Africa has been undergoing during the last 2 000 years or so. Direct effects of the introduction of domestic animals seen in the local archaeological record of Die Kelders relate primarily to a relaxation of the earlier Holocene pattern of seasonal movement, although hunting, gathering and fishing continued to be economically important.

### *Non-domestic animals*

The mammalian fauna was identified and analysed by R. G. Klein and K. Scott and is detailed in Table 27. This shows that the non-domestic group of animals once commonly hunted for food were largely those still prevalent in the area today. They comprise seals, small antelopes and dune mole-rats. Exceptions are the blue antelope, which is now extinct, and black rhinoceros, hippopotamus, and buffalo which have long been exterminated in the area. The bontebok is now restricted to protected areas and the vaal rhebok is extremely rare.

The animals most commonly hunted for food are discussed below under individual headings, while the other animals are included in a final section dealing with the role of hunting.

#### *Seals (Arctocephalus pusillus)*

According to ethno-historical references (Goodwin 1952a: 12), seals were easily clubbed to death. They occur in substantial numbers throughout the deposit. Their restricted birth season, which occurs in November–December, has been used by Parkington (1972: 241) to help establish seasonal occupation periods at Elands Bay Cave, a western Cape coastal site. R. G. Klein (pers. comm.) points out that 'none of the levels at Die Kelders has bones belonging to seals clearly younger than 5–6 months (age as determined by comparison



with aged specimens in the collection of the South African Museum), but the clustering of bones at or near the size of 5–6 months old is tightest in levels dating to around 2000 B.P.'. These layers contain only a few positively identified sheep. From layer 2 on, when sheep occur in quantity, the number of bones of seals older than 5–6 months is noticeably greater and there is an increase in the number of full adults. The implication may be that, prior to the introduction of sheep on a major scale, human populations were at Die Kelders for only a few months in winter, from perhaps May until July or August. Subsequently, with herding more established, local groups may have extended their stay until September or October (R. G. Klein pers. comm.).

### *Small Bovidae*

The genus *Raphicerus* is, after dune mole-rats, numerically the largest mammal genus represented at DK 1 (Table 27). Two species, *R. melanotis* (grysbok) and *R. campestris* (steenbok) occurred throughout the deposit, and these animals still survive in the area today. They are small (7–14 kg), inconspicuous, non-gregarious antelopes with somewhat differing habitat preferences. The grysbok prefers scrub-covered flats while the steenbok favours more open country (Dorst & Dandelot 1970: 264–266). Both may be characterized as selective browsers (Klein 1976: 171 from Jarman 1974). As indicated in Table 27, grysbok outnumber steenbok by an average ratio of more than three to one, and it may be assumed that the proportion remains the same for individuals not identifiable beyond genus level. On the basis of the known habitat preferences of the modern species and the present-day topography and vegetational cover, the information from DK 1 may be used to suggest that the cave occupants preferred to hunt or trap grysbok in the vicinity of the cave rather than to range further afield in search of steenbok. It may also be used to support the assumption that environmental conditions during the Holocene occupations of the cave were not much different from those of the present day. The marked drop in the frequencies of both species after layer 12 may also be taken to indicate an increasing reliance on meat from domestic animals.

### *Dune mole-rats (Bathyergus suillus)*

These animals are by far the most numerous group in the faunal assemblage. This is understandable in view of the fact that they are virtually confined to the soft sands and dunes adjoining the coast (De Graaff 1964: 172) and Die Kelders is on the margin of a large dunefield. Dune mole-rats are found in various kinds of vegetation, including fynbos, and their distribution shows no particular correlation with rainfall except that they do not occur at places with an annual rainfall of less than 100 mm (De Graaff 1964: 172).

Recent investigations into the suitability of using their pelts commercially have not met with success, owing to the large number required. This does not, however, rule out such use in the past. The meat of dune mole-rats is still eaten today, particularly in poorer country areas. It is not known how the animals



were caught during the midden occupations. A study (Department of Nature Conservation 1970) showed that their greatest activity occurs in July, when two dune mole-rats pushed up fifty-seven heaps as against only three during their lowest activity in February. This suggests that these animals would be more easily hunted during the winter.

#### *Micromammalian fauna*

The micromammalian fauna from the excavation was analysed by D. M. Avery, who is carrying out a study of micromammals from archaeological sites since these are considered to be sensitive environmental indicators. Avery's counts and comments are included as Appendix 2.

#### *The role of hunting*

The occupants at Die Kelders in the late Holocene were in part dependent on hunting for subsistence and the bulk of their kills was made up of the animals which were most easily caught and could survive heavy predation. Projectile hunting probably played a lesser role in that the main quarry, namely small antelope, dune mole-rats and seals, would most likely have been hunted with snares and traps or clubs. The largest game, elephant, rhinoceros and hippopotamus, are represented only by traces of bone or ivory fragments. This suggests that these animals were probably butchered at the kill sites, possibly after being trapped. Their small numbers indicate that their pursuit played a lesser role in the lives of the hunters, who seem to have directed most of their efforts to a very restricted area around the site.

The overall picture (Table 27) shows no marked changes in species composition during the time of the build-up of the midden, and a stable exploitation pattern can be postulated. However, the fact that layer 12 contains 81 per cent of the thirty-two species in the faunal list (excluding *Homo sapiens*) as against a maximum of about 50 per cent in the other layers (53% in layer 7 and 50% in layer 2) can be taken as further confirmation of the suggestion (p. 205) that the introduction of domestic stock to the area resulted in a decrease in the importance of hunting.

A fuller account of body part frequencies and distribution is in preparation by R. G. Klein.

#### PLANTS

The only plant remains found at Die Kelders were small patches of the estuarine grass, *Zostera capensis*, which occurred throughout the succession. There was no evidence of the remains of any edible plants, although these are known to be present in abundance in the area today. The sea also contains a number of edible seaweeds which would have been accessible to the cave dwellers during their shellfish collecting forays.

The absence of any traces of these or other plants from a matrix known to have been capable of preserving such material is surprising and suggests that

plant foods played little or no part in the diet of the Die Kelders people during their probably seasonal stay at the cave. This would seem to be an important conclusion since negative evidence is as valid as positive evidence. The explanation may be in the temporary seasonal replacement of plant-food collecting by shellfish collecting when groups were resident at the coast. This is to some extent supported by as yet unpublished data from the near-by site of Byneskranskop on the inland edge of the coastal plain. (Fig. 5) This site contains in its upper layers (broadly contemporary with DK 1) evidence not only of plant collecting in the form of corm cases and seeds, but also of exploitation of coastal resources: fish, shellfish and the stems of the giant kelp, *Ecklonia maxima*.

### THE SITE AS A LOCATION FOR PREHISTORIC SETTLEMENT

The position of DK 1 at the junction of three environmental zones—rocky shoreline, sandy beach and coastal plain—and within walking distance of a fourth—estuarine lagoon—enabled its occupants to exploit the resources of each. That they did so is shown by the artefacts and faunal remains from the site.

Marine food remains both in the form of fish and shellfish show the existence of a strong tendency to exploit the rocky shore in preference to all other zones. This may be interpreted as reflecting that zone's ability to 'sustain the richest and most varied populations in the sea' (Ager 1961: 12). It is, however, noteworthy that shellfish collecting in this zone was focused more on the easily accessible *Choromytilus* and *Perna* than on the larger *Patella* and *Turbo*, the collection of which might have required venturing into deeper water. Shellfish remains from the near-by sandy beach, though not necessarily all collected for food, show a similar preference for easily obtainable surface-scavenging *Bullia*, and though the collecting of *Donax* would have entailed a certain amount of digging in the tidal sand, this would not have entailed much physical effort. The presumed clubbing of seals must similarly have been carried out on dry land as these animals would have evaded capture in the sea.

The terrestrial fauna is composed mainly of small ground game, comprising tortoises, dune mole-rats and various small non-gregarious antelope. The capture of these animals by traps and snares would not have necessitated wide movement in the surroundings. There was probably a generally low dependence on the use of the poisoned arrow in hunting and a corresponding lesser need to track and pursue wounded prey for long distances. With plant-food collecting of little importance at the site, the only other resources to be required away from the sea-shore would seem to have been clay for making pots, ostrich egg-shells for containers and manufacturing beads, and firewood, none of which need have entailed long forays from the base.

Visits to the near-by lagoon(s) are shown by the regular occurrence of the estuarine grass *Zostera*, and by the presence of fish generally found in lagoons.

Such journeys may not have been frequent, judging by the small amount of these materials found at the site.

The main discernible change in a generally stable subsistence pattern is the increased importance through time of domestic stock. Although this did not alter the general pattern of the use of local resources, with the herding of sheep the availability of grazing in the surroundings would have become a new factor.

Die Kelders seems, therefore, to have been almost optimal as a location for at least seasonal occupation in the annual round of hunter-gatherer-fishers in the late Holocene. In view of the evidence provided by the excavation of the successful and selective exploitation of the rich resources of the local environment, it is tempting to wonder why the site was occupied for such a relatively short period in the history of the Later Stone Age peoples of the southern Cape. It may well be that the excavation, which sampled only a very small part of the total area of the cave complex, has fortuitously sampled only a part of the cave's occupational history, and that further excavations in other parts of the cave will reveal longer, or different, periods of the site's settlement history.

#### DIE KELDERS IN RELATION TO OTHER EXCAVATED SITES

As Die Kelders is situated in the southern Cape, characterized by a typical fynbos vegetation and a distinctive mammal fauna (Hendey 1974: 15), other sites in the same region dating to the Holocene, and to the later Holocene in particular, may be expected to show close parallels. This is, indeed, the case, and there is a general similarity in the kind of human adaptations evidenced in the archaeological record at these sites. It may eventually prove more informative to analyse the lower-scale differences between sites that reflect local habitat factors than to stress the gross similarities as is done here, but there are at present too few properly detailed studies. Table 28 lists a number of occurrences that provide data most relevant for correlation with Die Kelders and also indicates some of the differences in local setting or habitat.

#### SUBSISTENCE ACTIVITIES

As Die Kelders is a coastal site, the subsistence data relate primarily to the obtaining of food from the sea-shore. The variety of food found is equivalent to that found at both open station middens such as Gordon's Bay (Van Noten 1974), and cave-contained middens from Elands Bay on the west coast (Parkington 1972) to Nelson Bay Cave on the south coast (Klein 1972, 1974). Basically, the remains are those of shellfish, fish, marine birds and mammals, and terrestrial mammals, including domestic animals, from most pottery-associated levels. At coastal sites plant-food remains are notably rare or absent and it has been suggested that shellfish collecting replaced plant-food collecting in a seasonal round (Deacon, H. J. 1972). From this it follows that Die Kelders and other



coastal sites represent one facet of the mode of life of the Holocene populations in the southern Cape.

### *Shellfish collecting*

The practice of shellfish collecting is documented as early as the last interglacial at Klasies River Mouth (Voigt 1973*a*, 1973*b*). It is however, for the period from the terminal Pleistocene, i.e. from some 12 000 years ago, that the main archaeological evidence for shellfish collecting is derived. It was in this time that the thick and extensive middens at sites such as Matjies River were built up. There is some change in the variety of shellfish exploited through time in the longer sequences such as at Nelson Bay (Klein 1972: 186–189, 1974: 274) and this can be ascribed to changes in temperature and the coastal habitat with the establishment of post-glacial (Holocene) conditions. Die Kelders does not cover the longer span of time that would be expected to show changes in the shellfish fauna available. For example, the ratio of *Choromytilus* to *Perna*, shellfish which might be sensitive to sea temperatures and local environmental changes such as sand-covered and bare rocks on the shore, is constant and thus indicates that relatively stable conditions prevailed in the last 2 000 years. It is fairly certain that shellfish were collected from the immediate shore and not transported any distance. This is evident in the Die Kelders data and in the quantities of mussels, limpets and other rocky shore species that can be collected off the present shore. The situation is comparable to the Swartrif midden (Deacon, H. J. 1969) where mussels predominate, indicating collecting directed at an exposed rocky coast. The Swartrif midden shows clear differences from the near-by Storms River mouth midden where water conditions favour limpets. Although most middens indicate exploitation of species collected in the tidal zones, the low spring tide boundary was regularly crossed to harvest the larger shellfish species such as haliotids and, as at Bonteberg rock-shelter on the Cape Peninsula, even rock-lobster (Grindley 1967: 99). This would have required wading. The evidence from Bonteberg shows that the rock-lobster population was exploited intensively, whereas at DK 1 very little evidence of rock-lobster was recovered.

### *Fishing*

The fishing evidence from Die Kelders in its emphasis on *Pachymetopon blochii* (hottentot) indicates a local habitat factor, but this again finds a parallel in the Swartrif midden in the catches of *Diplodus* sp. (dassie) represented there. That the species represented in midden accumulations are relatively varied is further shown by the differing species frequencies identified from Nelson Bay Cave (Klein 1972: 190–192).

There is the suggestion in Goodwin's (1938*b*) Oakhurst report that fishing became more important later in the Holocene. This is partly supported by the Nelson Bay evidence and to a greater extent by that from Byneskranskop (Schweitzer & Wilson 1978). The Die Kelders evidence, however, does not



TABLE 28  
Basic data at other relevant sites.

Site	Radiocarbon dates	Type of site	Coastal zone	Mountain zone	Vegetation	References
Elands Bay	73510 ± 45 (Pta-687)	Cave	Benguela current	—	Strandveld type	Parkington 1972
De Hangen	90 ± 50 (Pta-167) to 1850 ± 50 (Pta-127)	Cave	—	Cape Folded Belt (Benguela current about 60 km distant)	Fynbos	Parkington & Poggenpoel 1971
Bonteberg shelter	2050 ± 95 (SR-166) 4505 ± 100 (SR-167)	Cave shelter	Western overlap	—	Fynbos	Beaumont 1963 Maggs & Speed 1967 Grindley 1967 Grindley, Speed & Maggs 1970 Deacon, H. J. 1974 Van Noten 1974
Gordon's Bay midden	2800 ± 40 (Grn-4372) 2980 ± 60 (Grn-4373) 3220 ± 55 (Grn-4374)	Open midden	Western overlap	—	Fynbos	
Klipkop Cave	None	Cave	Western overlap	—	Fynbos	Goodwin 1938a
Oakhurst	None	Cave shelter	—	Cape Folded Belt (about 6,5 km from Agulhas current)	Temperate Knysna forest	Goodwin 1938b
Nelson Bay Cave	1930 ± 60 (Grn-5703) to 2925 ± 35 (Grn-5702)	Cave	Agulhas current	—	Temperate Knysna forest (closed ever- green)	Inskeep 1965 Inskeep 1972 Deacon, J. 1978

TABLE 28 (cont.)

Site	Radiocarbon dates	Type of site	Coastal zone	Mountain zone	Vegetation	References
Hoffman's Cave (Robberg Cave East Guanogat)	3610 $\pm$ 110 (UW-204) 4180 $\pm$ 110 (UW-205)	Cave	Agulhas current	—	Temperate Knysna forest (closed ever- green)	Deacon, H. J. 1972
Matijes River shelter	5400 $\pm$ 250 (L-336E) 7750 $\pm$ 300 (L-336F)	Midden adjoining rock shelter	Above river mouth opening into Agulhas current	—	Bordering tem- perate forest	Louw 1960
Swarttrif	None	Midden adjoining rock shelter	Agulhas current	—	Bordering tem- perate forest	Deacon, H. J. 1970
Storm's River	None	Cave	River mouth open- ing into Agulhas current	—	Bordering tem- perate forest	Deacon, H. J. 1970
Klasies River Mouth	Cave 1 & 1a 2525 $\pm$ 85 (Gx-969) to 4695 $\pm$ 180 (Gx-973) Cave 5 2285 $\pm$ 105 (Gx-1397) to 4110 $\pm$ 160 (Gx-1378) 360 $\pm$ 80 (Y-1425) 1190 $\pm$ 100 (SR-82)	Caves	Agulhas current	—	Near existing margin of Knysna forest in area of fynbos and bush patches	Singer & Wymer 1969 Speed 1969 Voigt 1973a, b
Scott's Cave		Cave shelter	Agulhas current about 20 km distant	—	Fynbos	Deacon & Deacon 1963 Deacon, H. J. 1972 Klein & Scott 1974

contribute to this suggestion because of the short period involved, but it is obvious that in the late Holocene fishing was widely and competently practised.

### *Seal-hunting*

At all coastal sites that have been studied in detail, seal bones have been reported and clearly seals were an important source of food. Parkington's (1972: 241) excavations at Elands Bay led to the recovery of numerous seal bones (*Arctocephalus pusillus*, Cape fur seal) which showed surprisingly little variation in overall size. By measuring the mandibles and relating the results to the present-day observations of the restricted annual pupping season, Parkington was able to postulate that Elands Bay had been occupied during some part of winter or early spring. R. G. Klein & K. Scott (pers. comm.), on the basis of seal mandible size and additional information provided by measurements of tooth eruption, have been able to show a similar winter season of seal-hunting at Die Kelders, that later became longer. Independent confirmation of such conclusions may in future be gained from oxygen-isotope measurements on shells from these sites such as those made by Shackleton at Nelson Bay Cave (Klein 1974: 274).

### *Marine birds and fowling*

It would seem that sea birds were of importance as a source of bone for tool-making as well as food. Klein (1974: 269-270, 1977: 121) has noted that at Klasies River Mouth, a last interglacial site, it is the non-flying species that are represented, whilst by contrast the remains of flying birds are common at all excavated sites in the Holocene. At Nelson Bay Cave for example, gulls, cormorants and albatrosses were found (Klein 1972: 193, 1977: 121). Although fully detailed accounts are not yet available for Die Kelders, the same general pattern is apparent.

### *Terrestrial mammal hunting*

While midden accumulations clearly show a preference for coastal resources, the hunting of terrestrial mammals persisted in the exploitation pattern at all sites. In the Holocene in the southern Cape it is reasonably well established that the main antelope species hunted were those commonly found in the fynbos, notably steenbok, grysbok and duiker. The habitat requirements of the individual species in large measure determine the relative frequencies represented in samples as is shown by Klein's (1972, 1974, 1977) recent studies. The sites of Elands Bay, Nelson Bay, Klasies River Mouth and Scott's Cave all reveal a common emphasis on the small non-gregarious browsing antelopes mentioned above (Klein & Scott 1974). Klein's analyses have demonstrated that the distribution of these antelope, when based on late Holocene site data, coincides with their present distribution on the basis of vegetational patterns. Thus the Elands Bay area, with its open country and bush, contains both grey duiker (*Sylvicapra grimmia*), which is the only duiker found in open habitat

(Dorst & Dandelot 1970: 259), and steenbok (*Raphicerus campestris*), which is adapted both to open and bushy country. On the other hand, assemblages from sites in or near temperate forests, such as Nelson Bay Cave, Klasies River Mouth and Scott's Cave, include blue duiker (*Cephalophus monticola*), a typical browser found in forests (Dorst & Dandelot 1970: 258), as well as the more numerous *Raphicerus* species. At both Scott's Cave and Nelson Bay Cave the latter remains can be identified as the Cape grysbok (*Raphicerus melanotis*) which lives under the protection of scrub cover. Other animals common to sites to the east of Die Kelders are bushbuck (*Tragelaphus scriptus*) and bush pig (*Potamochoerus porcus*) which frequent the more wooded thickets and dense bush (Dorst & Dandelot 1970: 199). In the fynbos region, the better watered and grassier habitats to the east offered greater potential for hunting a wider variety of antelopes and pigs, and it should be expected that there would be differences between the faunal remains found at sites in environments similar to Die Kelders and the remains from sites to the north-west. At Die Kelders and sites in the western zone of the Cape Folded Belt, ground game such as dassies, tortoises and dune mole-rats had relatively greater importance.

### Herding

The Die Kelders data indicate that herding was practised in the southern Cape from at least 2 000 years ago. Remains of sheep, and possibly cattle, have now been recorded in the upper levels at the near-coastal site of Byneskranskop (Schweitzer & Wilson 1978), and the coastal sites of Elands Bay (J. E. Parkinson pers. comm.) and Nelson Bay Cave (R. G. Klein and R. R. Inskeep pers. comm.), at open middens (Avery 1974: 112), as well as at Scott's Cave in the Gamtoos Valley (Klein & Scott 1974). The best comparable data, however, comes from Boomplaas Cave (Deacon, H. J. *et al.* 1978; Deacon & Brooker 1976: 211; Klein 1978) where domestic animals formed a minor component some 2 000 years ago, but were well represented some 400 years later. The upper levels of Boomplaas are of similar (late Holocene) age to Die Kelders and provide good evidence for the local increase in herding. At both Die Kelders and Boomplaas, Klein's current studies show that the introduction of domestic stock had the apparent effect of reducing the importance of hunted wild animals. Explanation may be sought in competition for grazing between wild and domestic fauna associated with veld management practices such as increased burning of the veld to improve grazing, which would have affected wild antelope populations and distributions. The impact of the introduction of domestic stock into the southern Cape is a field study in itself. The modification of the pattern of seasonal occupation as a result of herding noted at Die Kelders has yet to be documented elsewhere.

### ARTEFACT MAKING

Traditionally, archaeologists have compared sites on the basis of their artefact content on the assumption that similarity in the artefacts is a measure



of similar temporal, economic and social relationships. This concept does have some validity at a general level, but it is also not consistently applied in many archaeological writings. In recent years, however, there has been a trend towards integrating the artefactual component with the other residues of human occupation in an attempt to provide an 'ecological' perspective.

Artefacts can be viewed as related to a variety of tasks, from the acquisition of food to the manufacture and maintenance of equipment and the performance of less materialistic tasks. They also incorporate stylistic attributes that transcend function.

### *Artefact assemblages at coastal sites*

#### *Stone artefacts*

While it is not possible to generalize about artefact assemblages from southern Cape coastal sites, evidence from such dated late Holocene sites as Nelson Bay Cave (Inskeep 1965: 577), Bonteberg shelter (Maggs & Speed 1967: 82, 84), Hawston (G. Avery pers. comm.), Gordon's Bay midden (Van Noten 1974: 125), and DK 1 suggests that the most striking feature is that the lithic artefacts at such sites are in the main irregular cortical or primary quartzite flakes with minimal retouch, giving the assemblages an impression of a general lack of refinement. Formal Holocene microlithic tools were found at the above sites but in extremely low numbers. Although this point is well known it has received little explicit discussion in the literature. The conventional explanation offered is that an easy and abundant food supply represented by shellfish did not require an elaborate technology (Clark 1959: 207; Goodwin 1952b: 137). H. J. Deacon (1976: 79), noting that small convex scrapers dominate assemblages at inland sites, suggests that their paucity at excavated coastal sites may be linked to the replacement of plant food gathering and processing by shellfish gathering. Perhaps the link here is in the kinds of tools and the activities undertaken by females and it could even include a seasonal factor as suggested in the discussion on bone tool function.

At sites even a short distance from the coast, such as Byneskranskop (Schweitzer & Wilson 1978) and Oakhurst (Goodwin 1938b: 306), where shellfish remains are found in quantities sufficient to indicate their having been a dietary component, microlithic artefacts are found in considerably increased abundance in the relevant assemblages. These coastal plain sites appear to reflect activities intermediate in character between those of the coast and the hinterland and their study is part of the South African Museum's general research programme through current studies at Byneskranskop.

#### *Bone artefacts*

The use of bone as a raw material for the making of a variety of formal tools at Die Kelders has close parallels at numbers of other coastal sites, as has been noted. Awls have received frequent mention. Projectile points are

apparently not as common, but it has been argued that trap-line hunting may have been more important in the eastern zone of the Cape Folded Mountain Belt (Deacon, H. J. 1972). Specific tool types such as spatulae have been reported from sites such as Matjies River (Louw 1960: 93–94). It is noteworthy that the small, double-pointed bone splinters thought to have served as fish gorges and found at Nelson Bay Cave (Klein 1972: 200, fig. 8; Deacon, J. 1978, figs. 10–11; R. R. Inskeep pers. comm.), Elands Bay (J. E. Parkington pers. comm.), and Byneskranskop (Schweitzer & Wilson 1978) have not been found at Die Kelders. The evidence from the other sites, however, suggests that this tool type is related to occupation periods considerably earlier than the late Holocene occupation of Die Kelders and does not occur in the contemporary sequences.

### *Shell artefacts and ornaments*

Utilized *Donax serra* valves found in DK 1 have also been recorded from Gordon's Bay midden (Van Noten 1974) and Oakhurst (Goodwin 1938b: 307–308). These are strong shells which would have provided scraping edges. By contrast *Choromytilus* shell 'crescents' recorded from Oakhurst (Goodwin 1938b: 307–339), Matjies River shelter (Louw 1960: 111), Klipkop cave (Goodwin 1938a: 216), and also found at DK 1, have yet to be convincingly demonstrated to be artefacts and not the chance products of natural fragmentation. *Choromytilus* shell is thin and brittle and would hardly seem to have any potential for use.

Ornaments are found at all southern Cape coastal sites where adequate sampling has been undertaken. At Die Kelders these are of the same form and made from the same species of shells as at the other sites. For example, at Scott's Cave some 650 km to the east, *Glycimeris queketti* and *Nassa kraussiana* beads were found and these are the commonest beads found at Die Kelders. Similarly, the sites of Matjies River and Oakhurst have produced *Cypraea* spp and *Conus* shells, as have other sites. Pendants made of *Turbo* shell also have a wide distribution.

### *Pottery*

Pottery is an important artefact class in the Die Kelders sample, perhaps the more so since this is one of the largest and earliest-dated samples from an excavated site in the southern Cape. The importance of the Die Kelders pottery sample is increased because it has been possible to make graphic reconstructions of seven vessels, most of them of unusual shape. Rudner, in an extensive survey of coastal pottery covering a distance of some 2 500 km and a total of 1 452 vessels, includes only 13 bowls (Rudner 1968: 621, table 2) whereas Die Kelders layer 12 alone has yielded 2 bowls. Of the complete or near-complete vessels analysed by Rudner (1968, figs 2–30), fifteen can be considered as morphologically comparable with the layer 12 pots and bowls. Most of the material studied by Rudner is from undated surface collections, and the material from published excavated sites (e.g. De Hangen & Scott's Cave) comes from horizons

with more recent radiocarbon dates than those for the DK 1 Holocene occupations.

Of the material studied by Rudner (1968) the globular pots from Oakhurst (his fig. 22: 2) and Tsitsikama Cave (his fig. 24: 1) are perhaps of most interest, since they come from excavated sites (Goodwin 1938*b*: Rudner 1968). The Oakhurst pottery is housed in the South African Museum (SAM-AA6990), and the globular pot in this collection resembles the DK 1 layer 12 pot, no. 1, in general form only: it is larger, thicker (c. 7,5 mm) and coarser in finish than the DK 1 pot and, indeed, almost all the material from layer 12. The Tsitsikama pot, in the Port Elizabeth Museum (PEM 87), is smaller than the DK 1 pot, but thicker-walled (7,0 mm) and, according to Rudner (1968: 534), '... in shape and thickness it is reminiscent of Bantu pottery'. The whole question of the relationship between the Later Stone Age Hottentot or 'Strandloper' pottery and that of the Iron Age peoples to the north is urgently in need of examination, since the early dates being obtained for Iron Age sites in the Transvaal (e.g. Mason 1973) reduce somewhat the apparent time gap between the appearance of herders in the southern Cape and Iron Age peoples in the eastern part of South Africa. On present evidence it would seem that herders with a distinctive pottery tradition preceded Iron Age pastoralists and agriculturists in South Africa and, because of geographical separation in the early phases, the 'Strandloper' pottery is little influenced by the Iron Age wares.

The spouted pot from layer 2 seems intermediate between Rudner's (1968: 455) types D1 and D2, and bears only a general resemblance to the eight examples he illustrates. Rudner (1968: 455) outlines the distribution of spouted pots at coastal sites from Namaqualand to East London as well as inland.

The Die Kelders pottery, therefore, displays several unusual morphological features which have little similarity to material from other coastal sites. This may well be related to temporal rather than geographical factors, a matter which can be re-studied when material from more excavated and dated sites becomes available.

### *Discussion*

The Die Kelders people, as would be expected, concentrated their subsistence activities on the exploitation of relatively abundant and accessible local resources. In the preceding comparisons certain differences are evident between resource utilization at DK 1 and other coastal sites, but these refer mostly to individual factors and almost certainly reflect variations in local environments. Differences become more striking at sites further from the coast, at which it appears that the eating of plant foods replaced the heavy reliance on marine resources revealed at coastal sites.

It seems evident, however, that the inhabitants of Die Kelders were part of a population in the Cape Biotic Zone whose subsistence economy was fundamentally similar, and based on an intimate knowledge of local resources. From the differences evident between coastal and inland sites, there appears



to have been a seasonally determined movement between the coast and the interior, and site-to-site differences may well reflect local environmental differences affecting the basic resource utilization patterns of the same group(s) moving seasonally (or for perhaps even longer periods) around what might loosely be described as their 'territory'.

As more information becomes available from a greater number of systematic excavations in the various environmental sub-zones of the southern Cape, it may well be possible to detect inter-group differences not solely attributable to environmental determinants as now seems the case; but these subtleties in the archaeological record are at present beyond resolution and remain a challenge for the future.

The artefacts from Die Kelders also conform to what is known of the technology of late Holocene population in the southern Cape. There are very obvious parallels that can be drawn between the kinds of artefacts at a general level and again at the level of more specific types of artefacts found at Die Kelders and at occurrences up to some 500 km to the east. The kinds of resources exploited at Die Kelders did not require a specialized technology outside that in use in this ecologically homogeneous zone.

### CONCLUSIONS

The excavation in the late Holocene midden member of the Die Kelders Cave sequence reported in this study is an initial set of observations aimed at an understanding of the ecology of the prehistoric peoples of the Gansbaai coast. The DK 1 deposit is in reality two windows into the past, one covering the last 2 000 years, and an earlier one in Upper Pleistocene times. The excavated deposit of the latter time range gives a contrasting picture of a people certainly technologically more primitive and perhaps lower on the scale of human biological development. The Die Kelders site is not unique in offering potential for research in the Upper Pleistocene-Holocene time range, broadly the last 100 000 years, and there are now numbers of known cave sites in the general southern Cape region covering part of this time range. All, like Die Kelders, are discontinuous sequences and the record of changes in human behaviour through time will be pieced together only from several observations. From the early Upper Pleistocene, there were apparently stable populations in the southern Cape who regularly used caves, thereby affording the archaeologist the opportunity of excavating deep, stratified deposits. At the Die Kelders Cave complex the opportunity is almost optimal in that the limestone country rock affords good preservation of bone in association with stone artefacts and a very large volume of deposit exists. The present excavations are essentially a test excavation—a vertical cut through the sequence, especially in the Upper Pleistocene levels. However, even on the limited scale and with the limited general objectives under which the excavations were originally undertaken, they do contribute directly to an understanding of the prehistory of the local area and the whole southern Cape.



The earlier occupation of the Die Kelders Cave complex took place when the sea-level was near that of the present day and during the main last glacial regression the cave became blocked with sands. In this time range the focus for occupation would have been on the then coastline across the exposed continental shelf and there is no record of human occupation in the cave. There is abundant evidence of widespread human settlement in the southern Cape in the late Pleistocene and early Holocene but the DK 1 part of the cave complex was reinhabited only in the late Holocene. Other parts of the complex may show on excavation a longer record of Holocene occupation. The Byneskranskop Cave, some 10 km from Die Kelders and excavated as part of the same research programme (Schweitzer & Wilson 1978), preserves a relatively complete record of occupation from some 13 000 years ago and supplements the Die Kelders data in this respect. The evidence from Byneskranskop shows that the terminal Pleistocene peoples in the region were exploiting coastal resources as well as hunting a variety of animals that included forms such as *Pelorovis*, *Equus capensis* and *Megalotragus* that became extinct at the end of the Pleistocene. In the early Holocene the population 'settled in' and adapted to the new environmental conditions of the post-Pleistocene. The Die Kelders late Holocene occupation relates to the end of this adaptive phase.

In the post-Pleistocene, as evidenced at Byneskranskop, there is the adoption of a fully microlithic technology, the pattern that has been detailed at sites in the eastern zone of the Cape Folded Belt, such as Wilton. In stratigraphic terms the Byneskranskop artefact sample includes the Wilton tradition as does the Die Kelders sample. Locational differences in the Wilton technology are largely reflected in the frequencies and variety of tools, and microlithic artefacts are poorly represented at coastal sites relative to inland sites in the time range under discussion. This is explicable when it is appreciated that technology is related to the kinds of resources exploited, and the location of settlement in turn is related to the availability of resources in the seasonal round. The Die Kelders Cave complex is a classic coastal situation which would be expected to, and does, reflect this in its technology, the coastal resources exploited, and in the apparent winter occupation. Byneskranskop Cave, although it contains a longer Holocene stratigraphic record, is an intermediate inland situation which provides some contrasts in the kinds of artefacts used and the food resources exploited. At this site partial dependence on marine resources is evident, especially in the upper levels, but these are generally subordinate to terrestrial resources. The full implication of the Byneskranskop Holocene occupation is still under study and cannot be anticipated here. It is apparent, however, that neither the Die Kelders complex nor the Byneskranskop site can be studied in isolation and, indeed, more widespread observations will be needed before the ecology of the Holocene peoples in this area can be fully understood. It is legitimate, however, in terms of this report to limit the focus to the Gansbaai coast, and to the last 2 000 years.

Although the Die Kelders people principally exploited natural resources,

the presence of remains of domestic stock in the deposits provides clear evidence that the cave occupants, if not herders themselves, were in contact with pastoralists. At a later stage, in layer 2, the evidence points to herding being well established in the area. In the context of South African archaeology Die Kelders provided the earliest dated evidence for the appearance at the Cape of herders. Who the early herders were is a pertinent question, the answer to which will depend on recovering human physical evidence from archaeological sites. Domestic stock have subsequently been recognized from numbers of similarly aged sites in the general southern Cape region and the social, cultural, demographic and ecological implications of the introduction of herding have added a new dimension to archaeology in the southern Cape. A point of interest that has emerged which may require further substantiation is that while in the initial (layer 12) deposits occupation of the site seems to have been restricted to the winter months, towards the end of the occupation (layer 2) the site was being occupied for longer periods, extending into late spring and perhaps even early summer. This is perhaps a result of increasing reliance on domestic stock for food whether or not this was owned by the cave occupants.

The investigations at Die Kelders are also significant in drawing attention to basic similarities in the subsistence economy and technology of populations in the Cape Biotic Zone in the later Holocene. It may appear unusual to stress homogeneity in the adaptation of human groups in a mosaic-type environment as the conclusion to the study of a localized area, but the evidence from Die Kelders has close parallels elsewhere. Perhaps the Gansbaai coast demanded of its prehistoric inhabitants a unique mixture of adaptive strategies to cope with local conditions, but by and large these are variations on the general theme of hunter-gatherer-fisher adaptation in the fynbos landscape in the Holocene.

As this is essentially a site report, the specific details of the pattern of local human adaptation are of importance. However, it is possible to view the Die Kelders evidence from both a static and a dynamic viewpoint. Clearly the local habitat, which in the last 2 000 years has remained largely unchanged, has limited the variability of behaviour patterns available to the prehistoric populations. It is thus possible to assume a measure of stability and consider the evidence in static terms. On the other hand, the time range sampled in the late Holocene midden revealed the introduction of domestic animals and pottery and implies changes in social organization and resource exploitation that demand a more dynamic view. The evidence from the site which principally samples two relatively discrete time ranges—the first and fifth centuries A.D.—shows that significant changes were taking place. Obviously the Stone Age of the southern Cape relative to the historical period cannot be dismissed as a kind of hazy past of no importance; and further excavations can only benefit by providing an increasing understanding of the ecology of not only the post-Pleistocene peoples on the Gansbaai coast but also of the prehistoric peoples of southern Africa.

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## REFERENCES

- AGER, D. V. 1961. *Principles of Palaeoecology*. New York: McGraw-Hill.  
AVERY, G. 1974. Open station shell midden sites and associated features from the Pearly Beach area, south-western Cape. *S. Afr. archaeol. Bull.* 29: 104-114.  
AVERY, G. 1975. Discussion on the age and use of tidal fish traps (visvywers). *S. Afr. archaeol. Bull.* 30: 105-113.



- AVERY, G. 1976. A systematic investigation of open station shell midden sites along the south-western Cape coast. Unpublished M.A. thesis, University of Cape Town.
- BARNARD, K. H. 1951. *A beginner's guide to South African shells*. Cape Town: Maskew Miller.
- BARNARD, K. H. 1954. *South African shore life*. Cape Town: Maskew Miller.
- BEAUMONT, P. 1963. The Bonteberg shelter—a progress report. *J. Sci. Soc. Univ. Cape Town* 1963: 20–21.
- BIDEN, L. 1954. *Sea angling fishes of the Cape (South Africa)*. Cape Town: Juta.
- BUCHANAN, W. F., HALL, S. L., HENDERSON, J., OLIVIER, J., PETTIGREW, J. E., PARKINGTON, J. E. & ROBERTSHAW, P. T. 1978. Coastal shell middens in the Paternoster area, south-western Cape. *S. Afr. archaeol. Bull.* 33: 89–93.
- CARTER, P. 1965. Bushman fishing as depicted in rock paintings. *Scient. S. Afr.* 2: 578–581.
- CLARK, J. D. 1959. *The prehistory of southern Africa*. London: Penguin Books.
- DAY, J. H. 1969. *A guide to marine life on South African shores*. Cape Town: Balkema.
- DEACON, H. J. 1969. Melkhoutboom Cave, Alexandria district, Cape Province: a report on the 1967 investigation. *Ann. Cape prov. Mus.* 6: 141–169.
- DEACON, H. J. 1970. Two shell midden occurrences in the Tsitsikama National Park, Cape Province. *Koedoe* 13: 37–49.
- DEACON, H. J. 1972. A review of the post-Pleistocene in South Africa. *S. Afr. archaeol. Soc. Goodwin Ser.* 1: 26–45.
- DEACON, H. J. 1974. *An archaeological study of the eastern Cape in the post-Pleistocene period*. Unpublished Ph.D. thesis, University of Cape Town.
- DEACON, H. J. 1976. *Where hunters gathered: a study of Holocene Stone Age people in the eastern Cape*. Claremont: South African Archaeological Society.
- DEACON, H. J. & BROOKER, M. 1976. The Holocene and Upper Pleistocene sequence in the southern Cape. *Ann. S. Afr. Mus.* 71: 203–214.
- DEACON, H. J. & DEACON, J. 1963. Scott's Cave: a Late Stone Age site in the Gamtoos Valley. *Ann. Cape prov. Mus.* 3: 96–121.
- DEACON, H. J., DEACON, J., BROOKER, M. & WILSON, M. L. 1978. The evidence for herding at Boomplaas Cave in the southern Cape, South Africa. *S. Afr. archaeol. Bull.* 33: 39–65.
- DEACON, J. 1969. Re-excavation and description of the Wilton type-site, Albany district, eastern Cape. Unpublished M.A. thesis: University of Cape Town.
- DEACON, J. 1972. Wilton: an assessment after 50 years. *S. Afr. archaeol. Bull.* 27: 10–45.
- DEACON, J. 1978. Changing patterns in the late Pleistocene/early Holocene prehistory of southern Africa as seen from the Nelson Bay Cave stone artifact sequence. *Quat. Res.* 10: 84–111.
- DE GRAAFF, G. 1964. *Dune mole rats*. Unpublished D.Sc. thesis, University of Pretoria.
- DEPARTMENT OF NATURE CONSERVATION. 1970. *Rep. Dep. Nat. Conserv. Cape of Good Hope*. 26: 142–144.
- DE VILLIERS, H. 1974. Human skeletal remains from Cape St Francis, Cape Province. *S. Afr. archaeol. Bull.* 29: 89–91.
- DORST, J. & DANDELLOT, P. 1970. *A field guide to the larger mammals of Africa*. London: Collins.
- ERICSON, J. E. & STICKEL, E. G. 1973. A proposed classification system for ceramics. *Wld Archaeol.* 4: 357–367.
- FITZSIMONS, F. W. 1912. *Snakes of South Africa*. Cape Town: Maskew Miller.
- FOX, F. W. 1966. *Studies on the chemical composition of foods commonly used in southern Africa*. Johannesburg: South African Institute for Medical Research.
- GOODWIN, A. J. H. 1935. A commentary on the history and present position of South African prehistory with full bibliography. *Bantu Stud.* 9: 291–417.
- GOODWIN, A. J. H. 1938a. Klip Kop cave Hermanus. *Ann. S. Afr. Mus.* 24: 211–219.
- GOODWIN, A. J. H. 1938b. The archaeology of the Oakhurst shelter, George. *Trans. R. Soc. S. Afr.* 25: 229–280.
- GOODWIN, A. J. H. 1946. Prehistoric fishing methods in South Africa. *Antiquity* 20: 134–141.
- GOODWIN, A. J. H. 1952a. Jan van Riebeeck and the Hottentots. 1652–1662. *S. Afr. archaeol. Bull.* 7: 2–53.
- GOODWIN, A. J. H. 1952b. Early man on the Cape Peninsula. In: Mabutt, J. A. ed. *The Cape Peninsula*. Cape Town: Maskew Miller.
- GOODWIN, A. J. H. & VAN RIET LOWE, C. 1929. The Stone Age cultures of South Africa. *Ann. S. Afr. Mus.* 27: 1–289.
- GRINDLEY, J. R. 1967. The Cape Rock Lobster *Jasus lalandii*. *S. Afr. archaeol. Bull.* 22: 94–102.



- GRINDLEY, J. R., SPEED, E. & MAGGS, T. 1970. The age of the Bonteberg Shelter deposits, Cape Peninsula. *S. Afr. archaeol. Bull.* **25**: 24.
- HENDEY, Q. B. 1974. The Late Cenozoic carnivora of the south-western Cape Province. *Ann. S. Afr. Mus.* **63**: 1-369.
- INSKEEP, R. R. 1965. A complex archaeological task at Cape cave. *Scient. S. Afr.* **2**: 575-577.
- INSKEEP, R. R. 1972. Nelson Bay Cave, Robberg Peninsula, Plettenberg Bay. *Palaeoecol. Afr.* **6**: 247-248.
- KENSLEY, B. 1973. *Sea-shells of southern Africa. Gastropods*. Cape Town: Maskew Miller.
- KLEIN, R. G. 1972. Preliminary report on the July through September 1970 excavations at Nelson Bay cave, Plettenberg Bay (Cape Province, South Africa). *Palaeoecol. Afr.* **6**: 177-208.
- KLEIN, R. G. 1974. Environment & subsistence of prehistoric man in the southern Cape Province, South Africa. *Wld Archaeol.* **5**: 249-284.
- KLEIN, R. G. 1976. The fossil history of *Raphicerus* H. Smith, 1827 (Bovidae, Mammalia) in the Cape Biotic Zone. *Ann. S. Afr. Mus.* **71**: 169-191.
- KLEIN, R. G. 1977. The Ecology of Early Man in southern Africa. *Science* **197**: 115-126.
- KLEIN, R. G. 1978. A preliminary report on the larger mammals from the Boomplaas Stone Age Cave site, Congo valley, Oudtshoorn District, South Africa. *S. Afr. archaeol. Bull.* **33**: 66-75.
- KLEIN, R. G. & SCOTT, K. 1974. The fauna of Scott's cave, Gamtoos Valley, south-eastern Cape Province. *S. Afr. J. Sci.* **70**: 186-187.
- KOLB(EN), P. 1738. *The present state of the Cape of Good-Hope* **1**. 2nd ed. Transl. by G. Medley. London: Innis & Manby.
- LOUW, J. T. 1960. Prehistory of the Matjies River shelter. *Mem natn. Mus. Bloemfontein* **1**: 1-143.
- MACCALMAN, H. R. & GROBBELAAR, B. J. 1965. Preliminary report of two stone-working OvaTjimba groups in the northern Kaokoveld of South West Africa. *Cimbebasia* **13**.
- McLACHLAN, G. R. & LIVERSIDGE, R. 1970. *Roberts' Birds of South Africa*. Johannesburg: Central News Agency.
- MAGGS, T. & SPEED, E. 1967. Bonteberg shelter. *S. Afr. archaeol. Bull.* **22**: 80-94.
- MASON, R. J. 1973. First early Iron Age settlement in South Africa: Broederstroom 24/73, Brits district, Transvaal. *S. Afr. J. Sci.* **69**: 324-325.
- MOODIE, D. ed. 1838. *The Record*. Photostatic reprint 1960. Amsterdam, Cape Town: Balkema.
- PARKINGTON, J. E. 1972. Seasonal mobility in the Late Stone Age. *Afr. Stud.* **32**: 223-243.
- PARKINGTON, J. E. & POGGENPOEL, C. 1971. Excavations at De Hangen. *S. Afr. archaeol. Bull.* **26**: 3-36.
- PÉRINGUEY, L. 1911. The Stone Ages of South Africa. *Ann. S. Afr. Mus.* **8**: 143-147.
- PETTJOHN, F. J. 1957. *Sedimentary rocks*. New York: Harper & Brothers.
- RAND, R. W. 1971. Marine resources of South Africa. In: CLAASSENS, J. W. & POTGIETER, H. J. eds. *Proteins and food supply in the Republic of South Africa*: 103-128. Cape Town: Balkema.
- RAU, R. 1969. Über die geometrische Landschildkroete (*Testudo geometrica*). *Salamandra* **5**: 36-45.
- RUDNER, J. 1968. Strandloper pottery from South & South West Africa. *Ann. S. Afr. Mus.* **49**: 441-663.
- RUDNER, J. & RUDNER, I. 1973. A note on early excavations at Robberg. *S. Afr. archaeol. Bull.* **28**: 94-96.
- SAMPSON, C. G. 1974. *The stone age archaeology of southern Africa*. New York, London: Academic Press.
- SCHALKE, H. J. W. G. 1973. The Upper Quaternary of the Cape Flats area (Cape Province, South Africa). *Scr. Geol.* **15**.
- SCHULZE, B. R. 1965. *Climate of South Africa. Part 8. General Survey*. Pretoria: The Weather Bureau.
- SCHWEITZER, F. R. 1970. A Preliminary report of excavations of a cave at Die Kelders. *S. Afr. archaeol. Bull.* **25**: 136-138.
- SCHWEITZER, F. R. 1972. The investigation of a coastal cave midden in the south-western Cape. *Palaeoecol. Afr.* **6**: 246.
- SCHWEITZER, F. R. 1974. Archaeological evidence for sheep at the Cape. *S. Afr. archaeol. Bull.* **29**: 75-82.

- SCHWEITZER, F. R. 1975. *The ecology of Post-Pleistocene peoples on the Gansbaai Coast, south western Cape*. Unpublished M.A. thesis, University of Stellenbosch.
- SCHWEITZER, F. R. & SCOTT, K. J. 1973. Early occurrence of domestic sheep in sub-Saharan Africa. *Nature, Lond.* **241**: 547.
- SCHWEITZER, F. R. & WILSON, M. L. 1978. A preliminary report on excavations at Byneskranskop, Bredasdorp district, Cape. *S. Afr. archaeol. Bull.* **33**: 134-140.
- SINGER, R. R. & WYMER, J. J. 1969. Radiocarbon date for two painted stones from a coastal cave in South Africa. *Nature, Lond.* **224**: 508-510.
- SMITH, J. L. B. 1949. *The sea fishes of southern Africa*. Johannesburg: Central News Agency.
- SPEED, E. 1969. Prehistoric shell collectors. *S. Afr. archaeol. Bull.* **24**: 193-196.
- STEPHENSON, T. A. 1944. The constitution of the intertidal fauna and flora of South Africa. *Ann. Natal Mus.* **10**: 261-358.
- STEYN, H. P. 1971. Aspects of the economic life of some nomadic Nharo Bushmen groups. *Ann. S. Afr. Mus.* **56**: 275-322.
- TANKARD, A. J. & SCHWEITZER, F. R. 1974. The geology of Die Kelders cave and environments: a palaeoenvironmental study. *S. Afr. J. Sci.* **70**: 365-369.
- TANKARD, A. J. & SCHWEITZER, F. R. 1976. Textural analysis of cave sediments: Die Kelders, Cape Province, South Africa. In: DAVIDSON, D. & SHACKLEY, M. eds. *Geoarchaeology: earth science and the past*. London: Duckworth.
- TAYLOR, H. C. 1961. Ecological account of a remnant forest near Stanford, Cape Province. *Jl. S. Afr. Bot.* **27**: 153-165.
- TAYLOR, H. C. 1972. The vegetation of South Africa with emphasis on the fynbos of the south-western Cape. In: *Cape flora*. Cape Town: The Board of Extra-Mural Studies, University of Cape Town.
- THACKERAY, F. & FEAST, E. C. 1974. A Midden Burial from Cape St Francis, eastern Cape Province. *S. Afr. archaeol. Bull.* **29**: 92.
- VAN NOTEN, F. L. 1974. Excavations at the Gordon's Bay shell midden, south-western Cape. *S. Afr. archaeol. Bull.* **29**: 129-142.
- VOGEL, J. C. 1969. The Radiocarbon time-scale. *S. Afr. archaeol. Bull.* **24**: 83-87.
- VOIGT, E. 1973a. Klasies River Mouth Cave: an exercise in shell analysis. *Bull. Transv. Mus.* **14**: 14-15.
- VOIGT, E. 1973b. Stone Age molluscan utilization at Klasies River Mouth caves. *S. Afr. J. Sci.* **69**: 306-309.
- WELBOURNE, R. G. 1973. Identification of animal remains from the Broederstroom 24/73 Early Iron Age site. *S. Afr. J. Sci.* **69**: 325.
- WILKINS, W. H. ed. 1901. *South Africa a century ago; letters written from the Cape of Good Hope (1797-1801)*. London: Smith Elder.
- WILLCOX, A. R. 1963. *The rock art of South Africa*. Johannesburg: Nelson.



## APPENDIX 1

### PRELIMINARY NOTES ON THE GEOLOGY OF DIE KELDERS, CAPE

By

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(With 1 table)

#### THE GEOLOGICAL SETTING

The archaeological cave site of Die Kelders (see Schweitzer 1970) is situated on a part of the southern Cape coast that preserves a complex and interesting late Cainozoic sedimentary record. The group of caves is uniquely situated at the southern extremity of Walker Bay, at the contact of the Table Mountain quartzite, the late Tertiary Bredasdorp beds, Pleistocene aeolianites, and recent dune-sands.

Die Kelders 1 is eroded along the contact of strongly jointed, folded Paleozoic quartzite and quasi-horizontal Bredasdorp strata, along what appears to be a planation surface locally cut at 7 to 8 m above m.s.l. (mean sea-level). These Tertiary beds grade up from interfingering, basal subangular conglomerates, breccoid lenses, and light-brown (Munsell hues 7,5 YR) ferruginized silts, to a well-stratified, very pale brown (10 YR), limestone (up to 90%  $\text{CaCO}_3$ ) with a residue of medium-grade quartz sand. Exposed to a thickness of 10 m or more, these well-indurated deposits require further study but relate to other late Tertiary (or early Pleistocene?) units described from the region by Spies *et al.* (1963) and inferred from the submerged continental shelf by Dingle (1971).

The Bredasdorp beds at Die Kelders are disconformably overlain by two major generations of aeolianite (see Table 1). Both are white (10 YR), semi-cemented, coarse sands consisting of ground-up molluscan debris, subangular comminuted quartzite grains, and subrounded quartz. Bedding of the older aeolianite typically varies from 4 to 22°, and a component of very coarse grains (5%) as well as residual weathering products (5% or more) renders sorting moderate. The younger aeolianite is less indurated, finer grained, less weathered and better sorted, with bedding dips of over 28°. These two generations of aeolian sands are hardly distinguishable in terms of texture or shell components from modern dune-sands (see also Walsh 1968), indicating close coastal proximity. However, bedding is different and reflects on foresets and topsets embanked against and ultimately sweeping over the top of the bed-rock cliffs, with little indication of the marked dunal topography (merging barchans) of today. Cumulative thickness is in excess of 20 m and a horizon of loamy, derived soil wash separates the two. It appears that Middle Stone Age artefacts



occur with this soil, suggesting that closer study of the aeolianite complex is certainly warranted.

#### THE CAVE SEDIMENTS

The temporal relationship of the aeolianites to the cutting of the Die Kelders caves remains to be determined. None the less, the caves are typical marine grottoes, excavated by wave-cutting and carbonate solution along the contact of the quartzite and Bredasdorp strata. The notches preserved in the back of the caves suggest a responsible sea-level initially at least 7 m above that of the present. However, the structural-lithological complexities impose caution on any simple sea-level interpretation prior to systematic examination of a larger coastal stretch (compare Davies 1972).

The oldest cave deposits are discontinuous flowstones and stalagmites, consisting of finely-banded, very pale brown (10 YR), cryptocrystalline calcite with a residue of opaline silica and medium-grade quartz sand. Disposition of these 'travertines' appears to indicate a sea-level slightly higher than today.

These initial calcite precipitates were followed by breccia accumulation, today recorded by only a few remnants of indurated and corroded, Bredasdorp-derived rubble. This breccia, which contains Levallois flakes of Middle Stone Age type *in situ*, very probably represents frost-weathered *éboulis secs* although the state of cementation and weathering precludes systematic, morphometric study. In this regard there are striking similarities to the frost-weathered rubbles coinciding with most of the Middle Stone Age occupancy of Robberg's Nelson Bay Cave, near Plettenberg Bay (see Butzer 1973a, 1973b; also Butzer & Helgren 1972).

The unconsolidated sedimentary sequence being excavated by Schweitzer (1970) is considerably younger, since practically all the initial travertine and breccia fill had already been removed by corrosion and mechanical erosion. In fact, it is difficult to explain this effective episode of re-excavation without resort to a period of m.s.l. at least a little higher than that of today.

The oldest, unconsolidated cave fill was no longer exposed in 1971, and the Middle Stone Age strata seen were limited to some 30 cm of weathered, oxidized (10 YR yellowish brown, 7,5 YR strong brown and 2,5 Y pale yellow, from bottom to top) and decalcified ( $\text{CaCO}_3$  2,3–5,3%) sands dipping gently to the back of the cave; pH values now range from 7,0–8,1. The textual spectra indicate a marked increase in grain-size towards the top (Table 1), with a coincident decrease in rounded quartz sands of more distant origin. Comparison with modern dunes and off-shore marine sands (Table 1) shows clearly that the shoreline was initially located well off-shore, implying a glacial-eustatic regression. The terminal strata indicate that a transgression was under way, although the shoreline was still located farther out than today. A detailed sediment column and faunal comparison through the whole of the Middle Stone Age complex promises to be quite informative.

Following the long period of weathering, during which some 75 per cent

of the Middle Stone Age sediment bulk was leached out, fresh aeolian sands accumulated in the cave. These are well-stratified, very pale brown (10 YR), coarse sands, with a pH of 8,6 and a little finer-grained than corresponding recent sediments (Table 1). They suggest a slightly lower sea-level, with more extensive sandy beaches in front of the cave, immediately prior to accumulation of the first Later Stone Age middens *c.* 2100 B.P. (see Schweitzer 1970).

The sediments of the late midden complex are primarily cultural, although similar sands continued to blow into the cave throughout the period of intermittent occupancy. A total of nine sediment samples were analysed from this part of the sequence, but the information is of limited implication for possible variability of the internal or external environment. Depending primarily on cultural components (ash, carbonized organic materials, shell, nacre, bone,

TABLE 1  
Texture of various sandy units at Die Kelders (non-carbonate residues).

	%CaCO <sub>3</sub>	595 $\mu$ -2 mm	210-595 $\mu$	59-210 $\mu$	37-59 $\mu$	37 $\mu$
Modern dune . . . .	59,6	3,3	77,2	17,4	0,6	0,9
Modern marine sand . .	85,9	1,8	51,2	28,7	4,0	14,3
L.S.A. aeolian sand . .	60,2	2,4	54,1	35,2	0,6	7,7
M.S.A. aeolian sand (-5 cm)	2,3	2,3	45,8	47,8	0,8	3,3
M.S.A. aeolian sand (-30 cm)	5,3	0,3	8,0	83,6	2,9	5,2
Younger aeolianites . .	67,1	0,2	58,4	37,6	1,1	2,7
Older aeolianite . . . .	79,8	5,1	60,3	27,8	1,2	5,6

artefacts and *debitage*) and their relative density, CaCO<sub>3</sub> content of the under-2 mm fraction ranges from 72 to 91 per cent, pH 7,7-8,6, electrical resistivity + 100-200 millivolts, and colour from white to greyish-brown (10 YR) or light brownish-grey (2,5 Y). The final 25 cm of deposit contain less quartz sand, but are increasingly calcified. A thin, localized calcite crust caps part of the interbedded middens and serves to emphasize that there has been no more than incidental aeolian accretion in the cave since abandonment *c.* 1350 B.P. (see Schweitzer 1970). This striking reduction of sand can best be explained by a return to modern sea-level shortly after 1500 B.P., with the water mark remaining at the cave entrance ever since.

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## REFERENCES

- BUTZER, K. W. 1973a. Geology of Nelson Bay Cave, Robberg, South Africa. *S. Afr. arch. Bull.* **28**: 97-110.
- BUTZER, K. W. 1973b. The question of Pleistocene 'periglacial' phenomena in South Africa. *Boreas* **2**: 1-11.
- BUTZER, K. W. & HELGREN, D. M. 1972. Late Cenozoic evolution of the Cape coast between Knysna and Cape St Francis, South Africa. *Quat. Res.* **2**: 143-169.
- DAVIES, O. 1972. Pleistocene shorelines in the southern and south-eastern Cape Province. Part 2. *Ann. Natal Mus.* **22**: 225-279.
- DINGLE, R. V. 1971. Tertiary sedimentary history of the continental shelf off southern Cape Province, South Africa. *Trans. geol. Soc. S. Afr.* **74**: 173-186.
- SCHWEITZER, F. R. 1970. A preliminary report of excavations of a cave at Die Kelders. *S. Afr. arch. Bull.* **25**: 136-138.
- SPIES, J. J., ENGELBRECHT, L. N. J., MALHERBE, S. J. & VILJOEN, J. J. 1963. *Die geologie van die gebied tussen Bredasdorp en Gansbaai*. Pretoria: Geological Survey of South Africa. Expl. Shts. 3419C, 3419D and 3420C, Geol. Surv. S. Afr.
- WALSH, B. N. 1968. Some notes on the incidence and control of driftsands along the Caledon, Bredasdorp and Riversdale coastline of South Africa. *Bull. Dep. For. S. Afr.* **44**: 1-79.



## APPENDIX 2

### THE MICROMAMMALIAN FAUNA FROM THE LATE STONE AGE LEVELS AT DIE KELDERS

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(With 2 tables)

Detailed analysis of the micromammalian remains from Die Kelders and other southern Cape archaeological sites is in progress. For this reason a brief comment only is given here.

The list of micromammalian species represented in the Late Stone Age levels at Die Kelders was compared with that for material obtained by Grindley *et al.* (1973) from owl pellets collected near Stanford. This modern locality, which lies about 10 km inland and north-east of Die Kelders, is the nearest so far found to the archaeological site. It was chosen for this reason and for the fact that it is thought that owls were also responsible for the accumulation of the Die Kelders material. The Stanford locality was in the banks of the Klein River with a surrounding habitat consisting of a 'fringe of *Phragmites* and macchia along the river encompassed by agricultural lands, rooikrans thickets and gum plantations' (Grindley *et al.* 1973: 266). The fauna from here does not appear to have been affected unduly by the effects of agriculture; *Rattus rattus* is a commensal species imported from Europe and may be excluded from consideration. One could probably expect a similar assemblage from Die Kelders today, even though it is on the coast, so that it seems not unreasonable to make the comparisons effected below. Because half of the Die Kelders specimens come from layer 12, the following remarks, although general, refer basically to that level.

The general impression given is that in the past the area supported a denser ground cover with more grass and that the climate was perhaps rather wetter than it is today. The relatively small number of some sand-loving species (*Chrysochloris asiatica* and *Tatera afra*) and the absence of others (*Cryptomys hottentotus*, *Georhynchus capensis* and *Gerbillurus paeba*) at Die Kelders support this view. It should be noted, however, that *Bathyrergus suillus* (Cape dune mole-rat) was found in the macrofauna so that there must have been sand, presumably littoral dunes, in the area. The presence of *Dendromus melanotis*, *Steatomys* cf. *pentonyx* and *Mystromys albicaudatus*, albeit in small numbers, points to the existence of a certain amount of grass. *Stomys* spp also eat mainly grass stems and weeds and *Rhabdomys pumilio* subsists mainly on similar green vegetation. Dense ground cover is attested by the presence of *Crocidura flaves-*



TABLE I  
Minimum numbers of individuals of micromammalian species represented in the L.S.A. levels at Die Kelders.

Species	Levels															Total	%
	1	2	3	4	5c	6	7	9	10	12	20	22					
Insectivora																	
<i>Chrysocolotis asiatica</i>	.	.	1	—	—	—	—	1	—	3	—	—	5			3,42	
<i>Crocidura flavescens</i>	.	—	—	—	—	—	1	2	—	5	—	—	8			5,48	
<i>Suncus dwarf shrew</i>	.	—	—	—	—	—	—	2	—	3	—	—	5			3,42	
<i>Myosorex varius</i>	.	1	1	—	1	1	3	3	2	23	—	—	35			23,97	
Total	—	1	2	—	1	1	4	8	2	34	—	—	53			36,31	
Chiroptera																	
<i>Geoffroy's horseshoe bat</i>	.	—	1	—	1	—	—	1	—	2	—	—	5			3,42	
<i>Cape horseshoe bat</i>	.	1	—	—	—	—	1	—	1	2	—	1	6			4,11	
<i>Cape hairy bat</i>	.	—	—	—	—	—	1	—	—	1	—	—	2			1,37	
Total	—	2	—	—	—	—	2	1	1	5	—	1	13			8,90	
Rodentia																	
<i>Dendromus melanotis</i>	.	—	—	—	—	—	—	—	—	2	—	—	2			1,37	
<i>Steatomys cf. pentonyx</i>	.	—	—	—	—	—	1	1	—	7	—	—	9			6,16	
<i>Mystromys albicaudatus</i>	.	—	—	—	—	—	—	—	—	1	—	—	1			0,68	
<i>Tatera afra</i>	.	2	—	—	—	—	—	—	—	1	1	2	6			4,11	
<i>Praomys verreauxi</i>	.	3	1	1	—	—	—	3	2	7	—	2	19			13,01	
<i>Rhabdomys pumilio</i>	.	—	—	1	—	—	1	3	1	11	1	4	22			15,07	
<i>Otomys irroratus</i>	.	1	1	—	1	1	2	3	—	9	—	1	19			13,01	
<i>Otomys saundersae</i>	.	—	—	—	—	—	—	—	—	2	—	—	2			1,37	
Total	1	6	1	3	—	1	4	10	3	40	2	9	80			54,78	
Total	1	9	3	4	1	2	10	19	6	79	2	10	148			99,99	

TABLE 2  
Comparison of the microfauna from the L.S.A. levels at Die Kelders with that from owl pellets found near Stanford.

DIE KELDERS	STANFORD			
	No.	%	No.	%
Insectivora				
<i>Chrysochloris asiatica</i>	5	3,42	12	8,70
<i>Crocodyura flavescens</i>	8	5,48	8	5,80
<i>Suncus varilla</i>	5	3,42	3	2,17
<i>Myosorex varius</i>	35	23,97	11	7,97
	Total	53	34	24,64
Chiroptera				
<i>Rhinolophus clivosus</i>	5	3,42		
<i>Rhinolophus capensis</i>	6	4,11		
<i>Myotis tricolor</i>	2	1,37	2	1,45
	Total	13	2	1,45
Rodentia				
<i>Dendromus melanotis</i>	2	1,37	5	3,62
<i>Sieatomys cf. pentonyx</i>	9	6,16	21	15,22
<i>Myatomys albicaudatus</i>	1	0,58		
<i>Tatera afra</i>	6	4,11	22	15,93
			1	0,72
<i>Praomys verreauxi</i>	19	13,01	1	0,72
<i>Rhabdomys pumilio</i>	22	15,07	2	1,45
<i>Otomys irroratus</i>	19	13,01	4	2,90
<i>Otomys saundersae</i>	2	1,37	9	6,52
			1	0,72
	Total	80	36	26,08
	Total	146	102	73,91
	Total	146	138	100,00

*cens*, *Myosorex varius*, *Rhabdomys pumilio* and *Stomys* spp, whereas *Praomys verreauxi* suggests a more scrubby environment, probably on rather higher ground. The high proportion of *Myosorex varius* at Die Kelders indicates that the environment was particularly suited to these animals' needs which includes a mean annual rainfall of about 500–700 mm. Whilst *Otomys irroratus* and *O. saundersae* are often found coexisting, it is thought that the former prefers a rather wetter habitat than the latter. There could, therefore, be some significance in the shift in dominance from one species to the other.

The presence of *Steatomys* cf. *pentonyx* at Die Kelders is possibly significant. Roberts (1951: 450) notes that *Steatomys* spp aestivate underground in nests of grass for part of the year. Assuming this to be the case, they would have been caught during the winter when they were active since they are not likely to have been aestivating in the cave. Assuming also that owls and human beings did not occupy the cave at the same time, this could lead to the suggestion that the human beings were there in the summer. Confirmation or destruction of this hypothesis will require further work.

#### REFERENCES

- GRINDLEY, J., SIGFRIED, W. R. & VERNON, C. J. 1973. Diet of the Barn Owl in the Cape Province. *Ostrich* 44: 266–267.  
ROBERTS, A. 1951. *The Mammals of South Africa*. Johannesburg: Trustees of 'The Mammals of South Africa' Book Fund.

### APPENDIX 3

#### HUMAN SKELETAL REMAINS FROM DIE KELDERS, CAPE

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Human skeletal remains from Die Kelders DK 1 consist of a recognizable burial of Late Stone Age association, other scattered bones not associated with this burial, and a few isolated teeth found in Middle Stone Age context.

The burial is represented by skull parts and other bones, all in highly fragmentary condition. One parietal is nearly intact, and most of the occiput can be pieced together. But the facial parts are badly broken, and the upper teeth are all loose, except for the deciduous lateral incisor, canine,  $dm^1$  and  $dm^2$  which are still in place in a fragment of maxilla from the right side. The crowns of all permanent upper incisors, one canine and several upper premolars are present, and the central incisors have roots which are partly calcified. It is difficult to assess the state of eruption of these anterior teeth, but  $M^1$  was clearly in place on both sides. One unerupted  $M^2$  crown is also present in the collection.

The lower jaw is more or less intact and contains the left deciduous molars and  $M_1$  as well as the right milk canine,  $dm_1$   $dm_2$  and  $M_1$ . The two permanent central incisors are in position but have been glued, and whether they were fully erupted at the time of death is uncertain. Both  $M_2$ 's are in their crypts. All this dental information suggests an age for the L.S.A. burial of 6-7 years.

Postcranial remains consist of vertebral fragments, a right scapula, both humeri (lacking epiphyses), and bits of ribs. Other pieces are small and generally not diagnostic. Measurements were not taken.





6. SYSTEMATIC papers must conform to the *International code of zoological nomenclature* (particularly Articles 22 and 51).

Names of new taxa, combinations, synonyms, etc., when used for the first time, must be followed by the appropriate Latin (not English) abbreviation, e.g. gen. nov., sp. nov., comb. nov., syn. nov., etc.

An author's name when cited must follow the name of the taxon without intervening punctuation and not be abbreviated; if the year is added, a comma must separate author's name and year. The author's name (and date, if cited) must be placed in parentheses if a species or subspecies is transferred from its original genus. The name of a subsequent user of a scientific name must be separated from the scientific name by a colon.

Synonymy arrangement should be according to chronology of names, i.e. all published scientific names by which the species previously has been designated are listed in chronological order, with all references to that name following in chronological order, e.g.:

Family Nuculanidae

*Nuculana (Lembulus) bicuspidata* (Gould, 1845)

Figs 14–15A

*Nucula (Leda) bicuspidata* Gould, 1845: 37.

*Leda plicifera* A. Adams, 1856: 50.

*Laeda bicuspidata* Hanley, 1859: 118, pl. 228 (fig. 73). Sowerby, 1871: pl. 2 (fig. 8a–b).

*Nucula largillierii* Philippi, 1861: 87.

*Leda bicuspidata*: Nickles, 1950: 163, fig. 301; 1955: 110. Barnard, 1964: 234, figs 8–9.

Note punctuation in the above example:

comma separates author's name and year

semicolon separates more than one reference by the same author

full stop separates references by different authors

figures of plates are enclosed in parentheses to distinguish them from text-figures

dash, not comma, separates consecutive numbers

Synonymy arrangement according to chronology of bibliographic references, whereby the year is placed in front of each entry, and the synonym repeated in full for each entry, is not acceptable.

In describing new species, one specimen must be designated as the holotype; other specimens mentioned in the original description are to be designated paratypes; additional material not regarded as paratypes should be listed separately. The complete data (registration number, depository, description of specimen, locality, collector, date) of the holotype and paratypes must be recorded, e.g.:

*Holotype*

SAM–A13535 in the South African Museum, Cape Town. Adult female from mid-tide region, King's Beach Port Elizabeth (33°51'S 25°39'E), collected by A. Smith, 15 January 1973.

Note standard form of writing South African Museum registration numbers and date.

7. SPECIAL HOUSE RULES

*Capital initial letters*

- (a) The Figures, Maps and Tables of the paper when referred to in the text  
e.g. '... the Figure depicting *C. namacolus* ...'; '... in *C. namacolus* (Fig. 10) ...'
- (b) The prefixes of prefixed surnames in all languages, when used in the text, if not preceded by initials or full names  
e.g. Du Toit but A. L. du Toit; Von Huene but F. von Huene
- (c) Scientific names, but not their vernacular derivatives  
e.g. Therocephalia, but therocephalian

*Punctuation* should be loose, omitting all not strictly necessary

*Reference to the author* should be expressed in the third person

*Roman numerals* should be converted to arabic, except when forming part of the title of a book or article, such as

'Revision of the Crustacea. Part VIII. The Amphipoda.'

*Specific name* must not stand alone, but be preceded by the generic name or its abbreviation to initial capital letter, provided the same generic name is used consecutively.

*Name of new genus or species* is not to be included in the title: it should be included in the abstract, counter to Recommendation 23 of the Code, to meet the requirements of Biological Abstracts.

FRANZ R. SCHWEITZER  
EXCAVATIONS AT DIE KELDERS,  
CAPE PROVINCE, SOUTH AFRICA  
THE HOLOCENE DEPOSITS













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